Popular Astronomy

Vol. L, No. 5 MAY, 1942 Whole No. 495

The Luminosities of Novae

By DEAN B. McLAUGHLIN

Introduction

There is a peculiar fascination about the distances and absolute magnitudes of novae. They seem always to lie just beyond our reach, tantalizingly close to the border-line of measurability, yet far enough to leave scant hope that any practicable improvement in the precision of parallax measures will ever yield an accurate value of the distance of an individual nova by the direct method. In the light of more recent work, we know now that the early observers who tried to measure the parallax of Nova Persei with the heliometer or with the filar micrometer were attempting the impossible. Unfortunately, hindsight is clearer than foresight, and failure was due to no fault of theirs.

But in contrast with the breakdown of direct methods, statistical and indirect lines of attack have given increasingly convincing results. So many different indirect methods now place the luminosities of novae within rather narrow limits that a general summary appears to be in order.

The methods may be grouped under the following headings:

A. *Methods depending on angular measures and known base-line or velocity.*
   1. Direct trigonometric parallaxes
   2. Secular parallax
   3. Nebular expansion parallaxes

B. *Methods depending on other distance criteria*
   1. Interstellar calcium line intensities
   2. Galactic rotation effect in interstellar line velocities
   3. Novae in extra-galactic systems of known modulus

C. *Miscellaneous statistical methods.*

The several methods and their results will be discussed in the order named.

Direct Trigonometric Parallaxes

The best photographic measures of parallax fail to give, for the individual nova, anything more than an indication that it is "beyond the pale." However, enough such measures are now at hand to justify the evaluation of an average of all. Table 1 contains the trigonometric parallaxes of ten novae, all reduced to the system of Schlesinger's Catalogue. Notes at the foot of the table explain the sources of all these values. Some were taken directly from the catalogue, two were revised, as explained in the notes, and some others were taken from original

sources and reduced to the system of the catalogue by application of the appropriate corrections. The stars are arranged in three groups: (1) the six brightest; (2) three fainter ones; (3) Nova Sagittae 1913.

TABLE 1

TRIGONOMETRIC PARALLAXES OF NOVAE

Nova		parallax		weight	Magnitudes Max.	Min.	Remarks
Aquilae	1918	—″002	±″004	6.2	—1.1	10.8	1
Cygni	1920	+.010	.005	4.0	+2.0	15.5	1
Geminorum	1912	+.003	.007	2.0	3.5	14.7	2
Persei	1901	+.006	.004	6.2	0.2	13.0	3
Pictoris	1925	—.003	.007	2.0	1.2	12.7	1
Herculis	1934	—.002	.011	0.8	1.4	14.5	4
Lacertae	1910	+.002	.007	2.0	4.6	14.4	1
Lyrae	1919	+.013	.009	1.2	6.5	(16)	5
Ophiuchi	1919	—.007	.010	1.0	7.4	(18)	6
Sagittae	1913	+.010	.007	2.0	7.2	15.2	7

REMARKS

1. From Schlesinger's Catalogue of Stellar Parallaxes.

2. Nova Geminorum. The Mount Wilson parallax, *Ap. J.*, **84**, 409, has been averaged with the value from Schlesinger. The Mount Wilson value, on Schlesinger's system, is +″004 ± ″006.

3. Nova Persei. The parallax by Bigourdan, + ″034 ± ″008, in spite of its small probable error, is discarded because it is simply out of all reason. The Yale heliometer value and Hassenstein's parallax both have such large probable errors that they have little effect, and might as well be excluded. The parallax given thus rests on three determinations: + ″005 ± ″005, Küstner; + ″005 ± ″007, Mount Wilson; + ″012 ± ″012, Oxford.

4. Nova Herculis. Van Vleck Observatory, *Astron. J.*, **49**, 59.

5. Nova Lyrae. *Mount Wilson Contribution*, No. 391.

6. Nova Ophiuchi. *Mount Wilson Contribution*, No. 290.

7. Nova Sagittae. *Mount Wilson Contribution*, No. 321.

P Cygni and η Carinae have been omitted, since they cannot be regarded as normal novae. The large proper motion of Nova Sagittae makes it plain that it is relatively near, and thus of unusually low luminosity, hence it is set apart from the others.

Averages may be taken in a number of ways. In Table 2 we give the weighted mean parallaxes and corresponding mean absolute magnitudes at maximum and minimum for the six bright stars, for the nine normal novae (excluding Nova Sagittae), and for all ten objects. The second column contains simply the weighted means of the figures from the second column of Table 1. The fourth and fifth columns were obtained by taking weighted means of the data from the fourth and fifth columns of Table 1, and then correcting them to absolute magnitudes by use of the parallaxes in the second column of Table 2.

The foregoing procedure is straightforward enough; the last two columns of Table 2 require a bit more explanation. As an example, take the first line of the table. Applying the probable error first with

the plus and then with the minus sign, we get the limits +".0052 and +".0008. The corresponding absolute magnitudes at maximum are —5^{M}.8 and —9^{M}.9; their median is —7^{M}.8, which appears in the sixth column. In a similar manner the remaining data of the last two columns were derived.

TABLE 2

MEAN PARALLAXES AND ABSOLUTE MAGNITUDES OF NOVAE

Average of:	parallax	prob. err.	Absolute Magn. Max.	Absolute Magn. Min.	Median Abs. Magn. Max.	Median Abs. Magn. Min.
6 bright	+".0030	±".0022	—7.0	+5.4	—7.8	+4.6
6 bright 3 faint	.0030	.0020	—6.1	+5.9	—6.8	+5.2
10 novae	.0035	.0019	—5.4	+6.3	—5.8	+5.9

The probable dwarfish character of Nova Sagittae justifies its exclusion and the consequent disregard of the last line of Table 2 as representing a group of average novae. The most dependable results would appear to be those given in the second line. In view of the way in which the probable error of the parallax applies, the *most probable* absolute magnitude will lie between the median, —6^{M}.8, and the value from the mean parallax, —6^{M}1. Accordingly, we adopt M = — 6.5 at maximum.* When this is corrected for general absorption of light in space, we get M = — 6.7.

SECULAR PARALLAX

Lundmark[1] calculated the mean parallactic motion of eleven novae and obtained a mean absolute magnitude — 7.1. Correction for the general absorption of light by interstellar matter gives M = — 7.6. Two of the stars he used were η Carinae and P Cygni, which are not at all to be admitted to the list of normal novae.

From the proper motions of the novae, Lundmark found a solar apex so far from the well-known position that it appears doubtful whether the results should be given much weight. It seems likely that the proper motions were not entirely freed of the motions of the comparison stars. Lundmark also carried out solutions based on both proper motions and supposed radial velocities.[2] But the latter depended chiefly upon the interstellar calcium lines, and for Nova Pictoris he used the velocity of the pre-maximum absorption spectrum. Neither of these types of data can be valid in such a solution, and results based on them must be discarded.

NEBULAR EXPANSION PARALLAXES

Studies of the spectra of Nova Persei and Nova Aquilae, and of their ejected nebulosities, leave no doubt that the body of gas which gave rise

*Ardent devotees of the theory of errors will be horrified by this crude procedure. In anticipation of their criticisms, it may be remarked that the character of the data does not appear to warrant a more rigorous treatment.

[1] *Pub. A.S.P.*, **34**, 207, 1922; **35**, 102, 1923.

[2] *Pub. A.S.P.*, **35**, 103, 1923; *Upsala Medd.* **30**, 58, 1927.

to the principal absorption and emission spectrum was the same as that which later became visible as an expanding nebula about the star. Evidence from Nova Herculis supports this view.

The spectrographic studies give the velocity of expansion of the gaseous shell; direct measurement shows the rate at which the angular diameter of the nebula grows. For a velocity v km/sec, apparent motion μ'' per year, and parallax p'', the relation is

$$v = 4.74\ \mu''/p''.$$

The complete data are assembled in Table 3, in which the columns contain, in order, the designation of four novae, the velocities of the gases, the rate of increase of radius of the nebula, in seconds of arc per year, the apparent magnitudes of the novae at maximum and minimum, the computed parallaxes, the resulting absolute magnitudes at maximum and minimum, and references to notes at the foot of the table.

TABLE 3

NEBULAR EXPANSION PARALLAXES OF FOUR NOVAE

Nova		Velocity km/sec	Expansion per year	App. Magn. Max.	App. Magn. Min.	Parallaxes	Abs. Magn. Max.	Abs. Magn. Min.	Ref.
Aql	'18	—1700	1".0	—1.1	10.8	0".0028	—8.9	+3.0	1
Her	'34	— 290	0.27	+1.3	14.5	0.0043	—5.5	7.7	2
Per	'01	—1200	0.4	+0.2	13.0	0.0016	—8.8	4.0	3
Pic	'25	— 410	1.0	+1.2	12.7	0.0020	—7.3	4.2	4
						Mean	—7.6	+4.7	
						Absorption	—0.3	—0.3	
						Corrected mean	—7.9	+4.4	

REFERENCES

1. Hubble and Duncan, *Ap. J.*, **66**, 59, 1927.

2. Baade, *Pub. A.S.P.*, **52**, 387, 1940. Mean rate for major and minor axes of nebula.

3. Humason, *Pub. A.S.P.*, **46**, 229, 1934.

4. McLaughlin, *Astron. J.*, **45**, 149, 1936.

Considered as individual parallaxes, these are surely entitled to the greatest weight of all. We may well question, however, whether these four novae represent the *average* of the class. It seems possible that the luminosity at maximum is related to the amount of matter ejected, and that in picking those which had visible nebulous shells we have automatically selected the most brilliant. Barring revision of the initial data, the writer would stick to the belief that these figures are correct for the four stars in question, but he is inclined to regard them as too bright for the average object of the class. It seems reasonable to believe that this may account for the difference between $-7^{M}.9$ and the mean value $-7^{M}.0$ which is derived later in this paper.

INTENSITIES OF INTERSTELLAR LINES

In recent years several investigators have established the statistical dependence of interstellar line intensity on distance. Although individual

distances calculated from the line intensities are likely to be in error as a result of local irregularities in the distribution of calcium, the average of a number of different values should be valid.

In Table 4 the determinations of luminosity by this method are collected. For convenience of comparison with the values given in other tables, the parallaxes are shown in the fifth column. The fourth column contains the modulus, m—M, which is calculated directly from the relation between distance and interstellar line intensity.

TABLE 4

LUMINOSITIES OF NOVAE FROM INTERSTELLAR LINE INTENSITIES

Nova		App. Magn. Max.	App. Magn. Min.	Modulus m—M	Parallax	Abs. Magn. Max.	Abs. Magn. Min.	Ref.
Gem	'12	3.5	15.	9.5	0".00126	— 6.0	+5.5	1
Aql	'18	—1.1	10.8	6.9	0.0042	— 8.0	+3.9	2
Aql	'18			(8.9)	0.0017	(—10.0	+1.9)	3
Cyg	'20	2.0	15.5	9.5	0.00126	— 7.5	+6.0	3
Her	'34	1.4	14.5	8.5	0.0020	— 7.1	+6.0	4
Lac	'36	2.1	15.3	9.5	0.00126	— 7.4	+5.8	5
Lac	'36			9.6	0.00120	— 7.5	+5.7	6
					Mean	— 7.25	+5.5	
					Absorption	— 0.4	—0.4	
					Corrected mean	— 7.6	+5.1	

REFERENCES

1. Struve (*Ap. J.*, **67**, 384, 1928) gives K in Nova Geminorum equal to the line in Nova Cygni. The writer confirms this on Michigan plates, and also finds equality of K in Nova Geminorum and Nova Lacertae, indicating a modulus of 9.5 magn.

2. Popper (quoted by Wyse), *Lick Pub.*, **14**, 131, 1939.

3. O. C. Wilson, *Pub. A.S.P.*, **48**, 229, 1936. The value for Nova Aquilae was given low weight by Wilson.

4. E. G. Williams, *M. N.*, **95**, 573, 1935, gives the total absorption of the interstellar lines. The writer has recalculated the modulus by means of Williams' later formula (*Ap. J.*, **83**, 305, 1936).

5. Merrill and O. C. Wilson, *Pub. A.S.P.*, **48**, 230, 1936.

6. Beals, *Victoria Pub.*, **6**, 335, 1937.

The agreement of the mean, $-7^{M}.6$, with values of the absolute magnitude obtained by preceding methods is fairly close. We may remark the possibility that this result is systematically a little too bright, since it depends on only the apparently brightest novae.

GALACTIC ROTATION EFFECT

This method was first applied by H. Spencer Jones.[3] The writer[4] used it to determine the luminosities of three novae. Since the sun is located in that part of the galaxy where the velocities of individual stars follow approximately Kepler's third law, the residual radial velocities of stars, located in directions making angles of about 45° with the direction of the galactic center, show an increase with distance from the sun.

[3] *Observatory*, **55**, 252, 1932.
[4] *Ap. J.*, **93**, 417, 1941.

Also, if we take the radial velocity of the interstellar lines and free it from the solar motion, the nearest stars show approximately zero residual velocity for those lines, regardless of direction in space. But for more distant stars, the galactic rotation effect becomes appreciable. It is given by the formula

$$V_r = r\,A \sin 2(l - l_o),$$

where V_r is the residual radial velocity, r is the distance of the calcium cloud from the sun, A is the Oort constant, 0.016 km/sec/parsec (the rate at which the residual velocity accumulates with distance), and l and l_o are the galactic longitudes of the star and of the galactic center, respectively. Since our novae are all close to the galactic equator, there is no factor to take account of galactic latitude.

From the above formula we may compute r, the distance of the absorbing calcium. On the reasonable assumption that the calcium is evenly distributed along the line of sight, the star is then at a distance $2r$. Corrections for general absorption of light in space can then be applied. As a result, the writer found the absolute magnitudes of three novae at maximum as given in the second column of Table 5. Dr. S. W. McCuskey, in a letter to the writer, suggested some corrections based on non-uniformity of absorption. These change the absolute magnitudes to those given in the third column, and those figures are to be preferred.

TABLE 5

LUMINOSITIES OF NOVAE, FROM GALACTIC ROTATION EFFECT

Nova		—Absolute Magnitude— First approx.	Corrected	Remarks
v356 Aquilae	'36	—5.5	—6.7	slow nova
Monocerotis	'39	—6.8	—7.1	
Ophiuchi	'19	—6.6	—5.7	slow nova
Mean		—6.3	—6.5	

There is some evidence that slow novae have lower luminosities than the average, and two of these were slow novae. As for Nova Monocerotis, its absolute magnitude involved an extrapolation back to its unobserved maximum, and the adopted value is rather conservative. If anything, these luminosities are lower than average.

This method has the advantage of increasing in accuracy with increasing distance,—up to a certain practical limit. It gives some promise of being quite powerful in its application to novae which occur at favorable longitudes, but it fails near the null points of the galactic rotation effect.

NOVAE IN EXTRA-GALACTIC SYSTEMS

The Magellanic Clouds

One nova or nova-like star, VZ Tucanae, has been found in the Lesser Magellanic Cloud.[5] It appeared in 1927, and its light curve was non-

[5] *Harv. Bull.*, **898**, **912**.

typical, with slow rise through nearly four magnitudes in 50 days, and a subsequent decline of three magnitudes in two weeks. We may regard it alternatively as a star of the Nova Pictoris type with an unusually large difference of magnitude between the pre-maximum halt and the maximum, or as a peculiar nova-like object related to Z Andromedae. Its brightest observed magnitude was $11^{M}.4$, and it probably did not get much brighter. Cepheids indicate a modulus, m — M, of $17^{M}.3$ for the Lesser Cloud, hence the absolute magnitude of VZ Tucanae was $-5^{M}.9$.

Three novae have been found in the Greater Cloud, but only two are usable for our purpose. The first, RY Doradus, 1926, was incompletely observed. Its brightest recorded magnitude was $12^{M}.4$, but it could have been easily two magnitudes brighter at maximum. Its fragmentary curve suggests that of a slow nova several weeks after maximum.[6] With a modulus of $17^{M}.1$ (from Cepheids), its greatest observed brightness corresponds to absolute magnitude $-4^{M}.7$.

The other two stars were typical novae. One in 1936 was caught close to maximum at apparent magnitude $10^{M}.8$[7]; a reasonable value for maximum is $10^{M}.6$. The other, in 1937, was observed almost precisely at maximum, if we can judge from the extremely rapid decline, at magnitude 10.7.[8] The corresponding absolute magnitudes of these two stars are $-6^{M}.5$ and $-6^{M}.4$.

We adopt $-6^{M}.5$ as the absolute magnitude of novae in the Cloud. This is likely to be a little faint, because we have been conservative in extrapolating to maximum. VZ Tucanae and RY Doradus cannot be said to conflict with this value.

The Andromeda Spiral, M 31

It is likely to be long indeed before there will be a substantial addition to the observational material on novae in the Andromeda spiral which was accumulated by Hubble[9] and continued by Mayall.[10] The Cepheids established a modulus of $22^{M}.0$; the mean apparent magnitude of the best-observed novae at maximum was $16^{M}.3$, according to Hubble, and an absolute of — 5.7 follows. However, the determination of magnitude at maximum is not so simple as it might appear. Gaps in the series of observations leave some doubt in all but a few cases, and the maximum had to be "calculated" by extrapolation, in which a standard form of light curve was used. The curve which Hubble employed was found to be somewhat too uniform in slope; the earliest stages of the decline were not steep enough. As a result, the extrapolated maxima were about a magnitude too faint, according to his revision in 1938. He

[6] *Harv. Bull.*, **847**, **886**, **898**.
[7] *Harv. Bull.*, **912**.
[8] *Popular Astronomy*, **49**, 268, 1941; *Harv. Bull.*, **915**.
[9] *Ap. J.*, **69**, 143, 1929.
[10] *Pub. A.S.P.*, **43**, 219, 1931.

even suggests that -7 is not too extreme for the true average absolute magnitude at maximum.[11] We shall be a little conservative and adopt $-6^{M}.7$.

Messier 33

The Cepheids in this spiral establish its modulus as $21^{M}.9$. Only five novae have been recorded in it, and published data are at hand for only three of them. The first two[12] were caught at undetermined stages of decline, at apparent magnitudes 17.2 and 17.9, corresponding to absolute magnitudes -4.7 and -4.0, but either of them could have been two magnitudes brighter at maximum. The third was probably observed nearer maximum, at magnitude 16.6,[13] and perhaps brighter,[14] so that its absolute magnitude was brighter than -5.3. The character of these data does not permit assignment of any weight in comparison with other material.

Miscellaneous Statistical Methods

Several other methods were employed by Lundmark.[15] Among them we may mention the "galactic dip" of the novae, the clustering of these objects in Sagittarius, and comparisons of their distribution and brightness with those of B and O stars. The luminosities determined by Lundmark ranged from $-5^{M}.4$ to $-6^{M}.8$, with a mean of $-6^{M}.1$. Since a number of faint novae were involved, the correction for absorption of light in space would probably change this mean to -7.

In view of the important role of absorption and obscuration by dark nebulae in determining the apparent distribution of distant stars, the galactic dip is of rather doubtful validity. The great wisp of obscuring nebulosity which causes the bifurcation of the Milky Way is an important factor, especially in the Sagittarius region where novae are most numerous.

The concentration of novae in Sagittarius is not open to the same objection. In the dense star clouds there are large numbers of cluster-type variables, and it seems permissible to assume that they are at roughly the same distance as the strong grouping of novae in the same area. Lundmark gave the absolute magnitude of the Sagittarius novae as $-6^{M}.7$. He regarded an earlier value, $-9^{M}.1$, as unreliable, because it was based on the probably incorrect assumption that the group was actually at the distance of the galactic center. Moreover, the value he assumed for the distance of the center was much larger than the one which is now commonly accepted.

The writer has made a rough calculation based on the assumption

[11] *Pub. A.S.P.*, **50**, 108, 1938.

[12] Hubble, *Ap. J.*, **63**, 258, 1926.

[13] Carpenter, *Pub. A.S.P.*, **41**, 118, 1929.

[14] Baade, *Harv. Announc. Card*, 74.

[15] *Pub. A.S.P.*, **35**, 95, 1923; *Upsala Medd.*, **30**, 58, 1927.

that the novae in Sagittarius and Scorpius are distributed within the same volume of space as the multitude of cluster-type variables there. This completely avoids the question whether we see as far as the galactic center or not. After eliminating probable foreground objects and insufficiently observed novae, there remain 16 whose maxima are sufficiently well established. Their mean apparent magnitude is 8.6. In the same region, 350 cluster-type variables have a mean apparent magnitude [16] of 14.8. Since their absolute magnitudes[16] are $0^M.0$, it follows that the novae have mean absolute magnitude $-6^M.2$. No absorption correction is needed, for the novae and cluster variables are assumed to be equally affected.

Combined Results

We now collect in Table 6 the results of the several methods of attack. No two people would agree as to just how to weight the different values, but unless we completely ignore several methods and exalt one alone, the average will not be seriously affected. The complete rejection of the value which depends on the secular parallax, and the increase of weight of the Sagittarius novae to unity, will only change the mean to $-6^M.9$. Except for actual systematic change of the individual values, there seems to be little chance of altering this figure materially. Apparently the luminosity of an average typical nova is determined within rather narrow limits.

TABLE 6

Luminosities of Novae by Several Methods

Method	M	weight
Trigonometric parallax	−6.7	1
Secular parallax	−7.6	½
Nebular expansion	−7.9	1
Interstellar line intensity	−7.6	1
Galactic rotation effect	−6.5	½
Magellanic Clouds	−6.5	½
Andromeda spiral	−6.7	2
Sagittarius	−6.2	½
MEAN	-7.0 ± 0.2	

Relative Brightness of Fast and Slow Novae

In an earlier paper the writer[17] pointed out that the naked-eye novae averaged much faster than the class as a whole. This suggests a possibility that fast novae average more luminous than slow ones. There are enough data to justify an attempt to evaluate the difference,—at least roughly.

In the Andromeda spiral, Hubble found $16^M.4$ as the average apparent magnitude at maximum for 57 novae. Inspection shows that this includes 11 slow novae[18] with an average apparent magnitude of $17^M.2$,

[16] The mean of maximum and minimum magnitudes.

[17] *Popular Astronomy*, **47**, 546, 1939.

[18] Nos. 15, 20, 40, 47, 53, 58, 67, 69, 75, 80, 84. The writer has examined the observations of each star individually, and has adopted magnitudes for the maxima which differ, in a few cases, from those given by Hubble.

and three other very slow objects,[19]—probably RT Serpentis stars,—of average magnitude $18^M.4$. The exclusion of these would revise the mean apparent magnitude of the remaining 43 objects (mostly fast, but still including some probably slow novae which were insufficiently observed) to $16^M.1$. Then, in line with Hubble's revision[11] (depending on an improved standard light curve) this last value must be raised to about $15^M.1$. The slow novae also should be revised a little, but considering the forms of their curves, we cannot correct them more than $0^M.3$. Accordingly, we adopt $16^M.9$ for 11 slow novae and $15^M.1$ for 43 fast ones in the Andromeda spiral.

In the Sagittarius region, the 16 novae we used earlier may be grouped into two means of 10 fast and 6 slow. Another group of 4 fast and 4 slow novae occurs in and near Aquila (foreground objects, as Nova Aquilae 1918, excluded). For both these groups we assume that fast and slow novae are at the same average distance, so that the difference of apparent magnitudes is equal to the difference of the absolute magnitudes.

From Table 3 we get means for two fast and two slow novae, which depend on the probably reliable nebular expansion rates. All the data are collected in Table 7, which is self-explanatory.

TABLE 7

DIFFERENCE OF LUMINOSITY OF FAST AND SLOW NOVAE

	—Fast—		—Slow—			
Group of Novae	m_f	No.	m_s	No.	$m_s - m_f$	Wt.
Andromeda spiral	15.1	43	16.9	11	1.8	2
Sagittarius	8.1	10	9.6	6	1.5	1
Aquila	6.5	4	8.4	4	1.9	½
Nebular expansion	—8.8*	2	— 6.4*	2	2.4	½
					Weighted mean	1.8

*Absolute magnitude.

The result appears definite: the average slow nova is nearly two magnitudes fainter in absolute luminosity than the average fast one, and all the groups are in rather good agreement. From the scanty evidence furnished by three objects in the Andromeda spiral, we may judge that the extremely slow stars of RT Serpentis type are more than a magnitude fainter than the average slow nova.

A Method that Failed

A few years ago the writer[20] made some calculations which he hoped might lead to independent determinations of the luminosities of novae, and for a time he believed the results. The method depended on the hypothesis that the increase of light involved the expansion of the outer strata of the star as a photosphere of steadily increasing area. Given two

[19] Nos. 26, 36, 39.

[20] *Astron. J.*, **45**, 145, 1936.

observations of the spectrum (from which the temperature could be inferred) and the apparent magnitude during the increase of light, it should be possible to calculate the *ratio* of the radii of the photosphere at the two times. Expressed mathematically,

$$M = 29{,}500/T - 5 \log R - 0.08,$$

where M is the visual absolute magnitude, T the absolute temperature, and R the radius in terms of the solar radius. Writing the equation twice, and subtracting, we have

$$\log R_2/R_1 = 5900/T_2 - 5900/T_1 + (M_1 - M_2)/5,$$

where the subscripts refer to two dates of observation. The radial velocity of the expanding gases is measured by the Doppler shift of the absorption lines towards the violet, so that we have

$$R_2 - R_1 = V(t_2 - t_1),$$

where V is the velocity (assumed constant) and t_1 and t_2 are dates of observation. From these two equations connecting R_1 and R_2 we can solve for the actual radii of the star at the two times.

Now the fallacy in the above process is simply this: we have no right to assume that the displacement of the *absorption lines* is a measure of the rate at which the *photosphere* or effective source of *continuous spectrum* is expanding. The violet shift simply tells how rapidly the absorbing atoms are approaching the observer. It is only logical to expect that the opaque cloud of gas, whose vague outer layers give the continuous spectrum, will lag behind the thinner gases in which the line absorption is produced. The "photosphere" does indeed expand, but it is simply an optical level in the outward-rushing cloud of gas, and it does not grow at the speed with which the individual atoms move.

In line with the fallacy which has been pointed out, the luminosities which were calculated by this method came out much higher than those which result from other methods discussed above. Considering individual cases, we would do best to compare these values with those which come from the nebular expansion method. The results are given in Table 8, and are compared with both "nebular" and "calcium" luminosities from Tables 3 and 4. All values are uncorrected for general space-absorption.

TABLE 8

		——Absolute Magnitudes——				
		Expanding photosphere	Nebular Expansion	Calcium	Δm_n	Δm_c
Per	'01	— 9.2	—8.8		—0.4	
Gem	'12	(—10.0)*		—6.0		(—4.0)*
Aql	'18	— 9.9	—8.9	—8.0	—1.0	—1.9
Cyg	'20	—10.1		—7.5		—2.6
Pic	'25	— 7.6	—7.3		—0.3	
Her	'34	— 7.0	—5.5	—7.1	—1.5	+0.1
				Adopted mean	—0.8	—1.4

*Omitted from mean.

The interesting feature of this comparison is that the differences between "expanding photosphere" and "nebular expansion" luminosities average about the same for the two fast and the two slow novae. In other words, the method fails by just about the same factor for both. From the second column we get the mean of three fast novae, $-9^{M}.7$, and the mean of two slow ones, $-7^{M}.3$. This gives another value of a difference of luminosity of slow and fast novae, about 2.4 magnitudes. The agreement may be fortuitous, but it is close enough to the difference determined by other methods to look as if there is some validity in the assumption of a constant "failure factor" for all cases in which luminosity is computed from magnitudes, temperatures, and radial velocities observed during the increase of light.

Conclusion

Throughout this paper a uniform system of magnitudes has been used, so that several novae are given luminosities slightly different from those published by the authors whose results have been used. This is believed to be preferable to a mere compilation of data. Any one of the methods alone would hardly be admissible as conclusive. The close agreement of all the various determinations is the convincing feature. And the fact that we have been able to "call our shots" in several cases gives added confidence in the separate values. The greater the variety of really valid (even though only rough) methods, the more reliable will be the final mean.

The luminosities of common novae have a dispersion of a few magnitudes about the value $-7^{M}.0$, approximately 50,000 times the sun's brightness. An occasional very brilliant one (for example Nova Aquilae 1918) may reach absolute magnitude -9, but such objects are rather rare. The slow novae are distinctly fainter than the average; absolute magnitudes of -5 to -6 may be considered typical for them. Possibly the little-known very slow objects like RT Serpentis are as low as -4 or even -3. Since Nova Aquilae and Nova Persei, whose luminosities were of the highest, were both very fast novae, there is some suggestion of a connection between luminosity and rate of decline, or a "life-luminosity relation." But there is no reason to believe that it is more than a statistical trend; a precise correlation is not implied.

Up to this point we have not mentioned supernovae. Baade[21] has determined their average absolute magnitude to be $-14^{M}.3$. Those of "Group II," however, are less brilliant, about $-12^{M}.5$.[22] But if there is a life-luminosity relation among common novae, it certainly does not extend to the supernovae. The latter have lifetimes which are *longer*,—not shorter,—than those of the fastest of the common ones. Their rates of decline are close to those of the *average* common novae. The writer

[21] *Ap. J.*, **88**, 285, 1938.

[22] Hubble, *Pub. A.S.P.*, **53**, 152, 1941.

has pointed out elsewhere[23] that a relation between ejection velocity and rate of decline, which holds for common novae, does not extend to the supernovae. Now, in the failure of the suggested life-luminosity relation, we may find a little added support for the view that supernovae are a distinct phenomenon and form a class apart; perhaps they are not to be assigned exactly the same causes as the common novae.

[23] *Ap. J.*, **91**, 369, 1940.

THE OBSERVATORY, UNIVERSITY OF MICHIGAN, JANUARY, 1942.

Tredyffrin Observatory, Berwyn, Pennsylvania

By H. B. RUMRILL

The observatory described herein is the realization of a dream of the years during which the writer's telescope, although in constant use at a window commanding a southern outlook, could not be utilized to its capacity. Delay in construction, however, permitted the careful consideration of many designs and the determination of various features, often by empirical methods only, but with the final result an observatory adequate for its intended purposes.

It has been mostly a "one man job," therefore a somewhat slow one, but with the advantages of uniformity in workmanship and a not unwelcome saving in labor cost—always the largest element of expense in building construction.

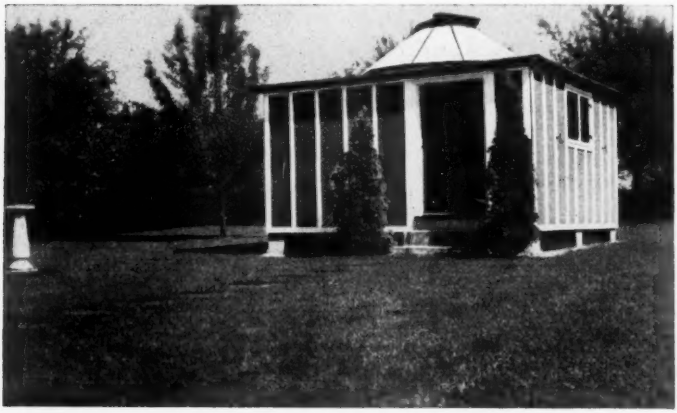
After preparing a number of plans and making all necessary alterations and changes *on paper*, work began with the cutting out of segments of one-inch white pine boards for the formation of the dome base and sill, each containing 36 segments laid on the "break joint" principle in triple thickness, and firmly screwed together after a period of seasoning.

Rather than shaping the various parts—studs, spreaders, window framing, etc.—*in situ*, these were made accurately from drawings that had been checked up from time to time, so that after the foundation and sill were finished the work on the rest of the project progressed more rapidly.

In something of the feeling expressed by Thoreau in his charming book, "Walden," and with as little ceremony, a space 16 feet square was cleared of sod, and excavation made for a central pier of concrete and eight concrete foundation pillars. The excavation for the pier was thought sufficiently deep when four feet below grade, whilst the pillar holes were dug to a depth of 30 inches or more as being well below the frost line. Beneath the top soil there lies a stratum of heavy clay, with an admixture of shale, which increases proportionately with the depth, and the holes were well tamped to insure a good foundation.

The forms for pouring concrete for the central pier and the founda-

tion pillars were all made in one connected series (the sides measured to an inner length of fourteen feet), this method assuring not only good alinement of pier and pillars, but their correct location with relation to each other, along with excellent leveling. The central pier is 30 inches square at top and weighs nearly four tons, and the foundation pillars are 12 inches square on top, weighing about five hundred pounds each. The steps were made separately.



TREDYFFRIN OBSERVATORY AND SUNDIAL, BERWYN, PENNSYLVANIA

The next procedure was the laying of the sill, followed by the placement of the joists. The lumber used for these, as well as for the corner uprights, was 3×6 hemlock; the sill members and corner uprights each consisting of two pieces nailed together so as to form 6×6 units. The sill timbers were laid on edge, with the corners overlapping horizontally, and fastened with 3/8-inch lag bolts, 6 inches long.

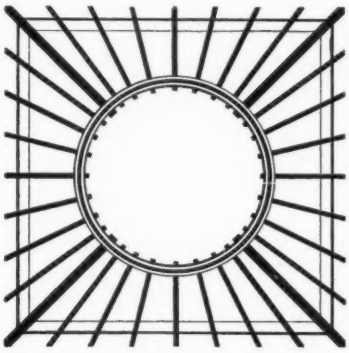
The joints were set in mortises cut in the inside timbers of the north and south sills, and tenoned on each end to fit closely. The spacing between the joists is 12¼ inches, which brings two of them close to the east and west sides of the central pier. These are connected on the north and south sides thereof by short sills, of 3×6 timbers (mortised and tenoned as in the case of the main sill members), fastened underneath to a pair of 2×6 pieces which are in turn screwed fast to the long side joists. Additional reinforcement was provided by longer pieces of 2×4 fir which connect the joists underneath on two sides of the central square thus produced. In addition to being tenoned into the sills, the outer ends of the short joists rest on two of the central concrete pillars. The telescope pier is thus isolated from the flooring, at the same time providing a strong framework for the latter at its weakest point.

On two sides of the central framework there is a double row of

diagonal "bridges," of 2×4 fir, between the joists. These were cut carefully to a neat fit. It was also found of advantage to reinforce the joists crosswise, underneath, between the pier and central east and west pillars with 2×6 timbers abutting against the latter; while, for resisting the pressure of the bridges against the east and west walls, two steel tie rods were introduced centrally through the joists and wall timbers, and fastened by nuts on each end. The floor is double, with the lower boards laid diagonally, and the upper ones (of oiled oak) crosswise of the former and of the joists, making a very substantial construction.

The sides of the telescope pier are faced with a ½-inch cork composition made by the Johns-Manville Company, enclosed by a $1 \times \frac{3}{4}$ molding. This material does not transmit vibration, nevertheless it is not placed tightly against the pier and fills up the gap which would otherwise be left between it and the floor.

The corners of the building framework are strengthened at top and bottom by struts placed diagonally, those at the bottom being fastened with 6-inch lag bolts. All these timbers and the lower flooring were treated with creosote oil, while between the double floor was inserted a thickness of heavy building paper.



PLAN OF CANTILEVER RAFTERS, TREDYFFRIN OBSERVATORY, BERWYN, PENNSYLVANIA

In the formation of the roof, which lies at a low angle, 36 fir timbers 2×4 were laid radially (doubled at the corners)—mortised and screwed down to the wall plate, and having the inside ends recessed to hold the lower circle or sill of the dome, to which they are solidly screwed. Much care was required in designing and cutting these rafters, which act as cantilevers, the lower dome ring thus becoming the keystone of an arch.

Further, in cutting the mortises and recesses, constants of measurement were employed in such a way as to make the roof sheathing slight-

ly convex at the centre of each side of the dome sill parallel with the eaves. The support thus contrived is exceedingly rigid and would carry a much greater weight than that of the dome, which is approximately 500 pounds.

On top of the dome sill an iron track is screwed, which was first wrought to a true circle, then sawed into quadrants. The section of this track is 1″ × ¾″, and it was placed in the centre of the ring, which is six inches wide. Particular attention was given the symmetrical location of the screw holes in order that the screws would not strike any of the joints.

The wheels carrying the dome on the iron rail are six in number, made of bronze, and flanged like railroad car wheels. They ride in brackets, on brass axles, and are so placed as to allow a minimum of "play."

The dome is a twelve-sided figure, diameter ten feet at the base, sheathed with half-inch tongued and grooved boards, and covered with painted canvas. It is flashed with lead and is purposely low (height four feet above the base of the lower ring) to avoid danger from high winds, and the closure of the slit, which is two feet wide, extending beyond the zenith, is by means of a canvas shade, with a strong roller at bottom. The shade was treated with paraffin dissolved in gasoline, is reinforced by a number of flat metal rods, and slides between a pair of copper sheaths.

The top of the slit lies at a slight angle (about that of a two-foot chord of a hemispherical dome of similar diameter) and a pair of small hard wood rollers lifts the weight of the shade at the angle where the slit ribs are joined. The shade is controlled by a stout cord, waxed, passing over pulleys and through screw eyes, and lies as flat as a board. The idea originated in Ellison's book on the construction of telescopes and observatories, but the plan followed in this instance is merely the reversal of the position of the ordinary window shade, although of stouter construction.

One great advantage of this method is the avoidance of the mechanism necessitated by wooden shutters, and the canvas shade can be fixed at any desired distance from the bottom. The control cords run at the sides within grooves made by turning up the copper sheaths, this having been done initially, however, to prevent rain from spreading over the edges of the shade into the building.

On three sides of the observatory are large plate glass windows, sliding horizontally within the walls, for the comfortable study of the constellations in cold weather, the building being heated electrically at such times (not of course when the telescope is in service). The window openings are covered by old-fashioned batten shutters for protection of the plate glass.

The rotation of the dome is performed by means of a yacht steering-wheel placed on the wall at the right of the door, connecting by a link-

belt sprocket chain with a bronze axle under one of the central rafters, which in turn actuates a wheel in friction contact with an inner ring of ash fastened flush with the upper surface of the dome ring. The composition wheel was made for this purpose by the Charles Bond Company.

A thick layer of broken stone underlies the building for protection from damp, while ventilation is effected by lattice framing under the sill, and the interior is insulated by a covering of half-inch "homosote." For the covering of the roof and sides three-ply "ruberoid" was used.

There are many other details of minor importance embodied in the construction of "Tredyffrin Observatory," one purpose of which was the provision of a sort of astronomical studio of sufficient size to accommodate the writer's collection of observatory annals, astronomical periodicals, and a considerable working library on the subject.

North of the building is a sun-dial designed and presented by past-President Rosengarten of the Rittenhouse Astronomical Society. Its motto—"Time is—Time was" (Bacon)—is so fitting as to require no comment.

BERWYN, PENNSYLVANIA.

Errors in "Marvelous Voyages—II"

In the February (1942) issue there appeared an article under the title Marveyous Voyages—II, which consisted of a summary by Laurence J. Lafleur of two of the scientific romances of Edgar Rice Burroughs, "The Center of the Earth" and "The Martian Series." It was there intimated that readers might discover certain scientific inaccuracies in these writings. It was suggested that such errors be reported and that they would be considered and published if deemed of sufficient importance.

Dr. Lafleur, himself, has pointed out the list of errors which follows. Readers will be interested in studying these comments and comparing them with the original article. Some may, indeed, detect errors in the list of errors. Such a situation might lead to an interesting discussion with Dr. Lafleur, which he would welcome. EDITOR.

THE CENTER OF THE EARTH

1. A hollow sphere could not be formed by the method described. When a solid crust formed on the outside, the pressure in the interior would be such that no matter what its temperature it would be solid, or liquid, or a gas of density greater than that of the surface solids.

2. If a hollow sphere formed, it still would not be stable.

3. Inside a hollow sphere the attraction of the crust would be precisely nil in every part. The only attraction would be the mutual attraction of objects within the sphere, which would tend slightly to make

them gravitate to the center. Against this there is centrifugal force, which would give an acceleration of less than .06 feet per second per second to an object on the interior equator, compared to g = 32 feet per second per second at the surface. Thus a 150 lb. man would "weigh" less than four and a half ounces. At the poles he would weigh zero.

4. A central sun would not stay put, even if nebulous and hot matter could exist under these circumstances.

5. A central collection of gaseous matter could not do much heating, since it would have no source of energy equivalent to that of stars.

6. An internal surface could never cool by radiation as does the external surface. If the central sun supplied heat constantly, the internal temperature would rise to several hundred thousand degrees. Alternatively, if the temperature is to remain near that of the surface, the central sun could not supply more heat than escapes to the surface through 500 miles of solid (including ice layers), and would be almost completely cold and non-luminous.

7. Assuming this "sun" to be miraculously held in place, it would have diameter of just under 32 miles (it appeared to be the same size as the real sun). An object revolving around it, if solid (and it could be nothing else), would have no perceptible motion and would be of imperceptible size.

8. Oil fuel needs oxygen to burn, hence oxygen for fuel must have been carried; could have been used to replenish atmosphere.

9. Not enough oil fuel could be carried to provide energy for digging more than a few miles, if that.

10. Even an engine-power more than 1728 times what is now in existence could not dig through rock at anything approaching a speed of seven miles an hour.

11. Both the motor and the friction of the drill would create enough heat to cremate the travelers. This heat has been entirely ignored.

12. There is absolutely no basis for the assumption of ammonia and ice, unless it be a vague reference to the interior of Jupiter.

13. The temperature of ice is not 32 degrees, except when melting or freezing, or when ice and water exist in contact. Ice sandwiched between strata 10 degrees below zero would be ten degrees below zero.

14. The direction of gravitation would remain central throughout the trip.

15. Life arising independently would not produce forms identifiable with our own.

16. If so, the author should at least be consistent, and not have both late Caenozoic and Mesozoic forms.

17. Surface and interior species could not be so similar as to permit intermarriage.

18. If species were so similar, the visitor from the surface would carry diseases which would decimate the population of the interior, and perhaps *vice versa.*

19. The notoriously brainless dinosaur is a poor selection for a race to have culture.

20. The author adopts the popular idea of hypnotism, which is completely erroneous. Hypnotism can never make a person do anything he wants not to do.

21. Even if there were no day and night, any physical process would serve to mark time. Biological and psychological processes could not be much less definite than with us.

The Martian Series

1. Mars is only occasionally 48 million miles from the earth. This figure is the difference between the average distances from the sun of the two planets.

2. The heat of the sun, ignoring atmospheric differences, would be less than half that on earth in equivalent positions. Even allowing for a thin atmosphere, then, the heat would not be remarkable.

3. The sun would be noticeably smaller, and one would suppose that this would be one of the first things recounted by a traveller to Mars, but Burroughs never mentions it.

4. And the horizon would be much nearer: not only nearer in fact because of the smaller size and greater curvature of Mars, but still nearer in appearance because of the greater clarity of the thin atmosphere.

5. The "lower air pressure" would have no appreciable effect upon the motions of a human being on Mars.

6. Assuming that an average healthy man can jump three and a half feet, raising his center of gravity two feet, he would be able to jump not less than seven feet on Mars, and not more than 9.7 feet. (For details of the theory, see section III of the quiz in the January issue of *Sky and Telescope.*

7. Burroughs gives the distances of the moons from the usual tables, which give center to center distances. But an observer on Mars would be concerned with the distance from the surface, which, when the nearer moon is at the zenith, is hardly more than half the distance. The difference between the zenith and horizon distances would be very noticeable.

8. In the periods of revolution Burroughs has again taken figures from a table without understanding them. Phobos would go around Mars three times in a day and night, but not in a night alone. Furthermore, the observer is also carried around by the planet's rotation, so that the moon would make just one revolution (apparent) a night.

9. The apparent period of the farther moon is over five days. And an observer would notice that the apparent motions are in different directions.

10. The apparent diameter of the nearer moon at the zenith is only three tenths that of ours; at the horizon hardly more than 15 hundredths.

11. The farther moon would show a diameter less than one-fifth that of the nearer one.

12. The brilliance of the nearer moon is therefore about four percent that of ours, of the farther sixteen hundredths of one percent. The moonlit nights would hardly be as bright as Burroughs insists.

13. And in addition the nearer moon would be eclipsed whenever it is near totality.

14. The nearer moon would not be visible from the pole.

15. There are four distinct colors in the spectrum. Popular usage gives six names. Where does Burroughs get seven?

16. There are many additional "rays," but they would not be visible to human eyes even if the human being travelled to Mars.

17. The description of the ninth ray is pure mystification. Assume an ether if you like, it would then always be in contact with everything. How would you treat a ray electrically? And how would you pump a ray? And what are "certain proportions of refined electric vibrations"?

18. The ray of repulsion cannot be really entertained as a theory If so an object would never be visible to a person located below it.

19. Magnetism could never be used for elevators. The power of a magnet falls away rapidly with the distance (as the third power).

20. As in the case of the underworld, life on Mars should not be similar to that on earth, or if so should at least be consistently so. The question of disease is also the same.

21. But marriage with a Martian is worse than marriage with the underworld girl, because the former is oviparous and fundamentally different from human beings.

22. One rare mammal on Mars, but there are apes and men!

23. How could the "woman" be visibly identical with men and "not a mammal"?

24. Is the "Tree of Life" a reminiscence of the purely diagrammatic tree of life in our biology?

25. A single tree cannot evolve, no matter how long it lives.

26. Evolution takes place, in any case, only by the pressure of adaptation to environment. But this factor is missing in the described evolution.

27. If evolution could nevertheless be so fantastically different from

evolution as we know it, it could hardly produce any creature remotely similar to creatures found on earth.

28. It is not particularly plausible that Martian animals would develop muscular power in proportion to planetary gravitation. Biological structures being similar, the difference would probably result in larger sized animals, or speedier animals, or more powerful animals.

On the Balancing of Equatorial Telescopes

By G. VAN BIESBROECK

A very great variety of observing instruments is in use in astronomical work. Some are small and of extreme simplicity: visual observers of variable stars for instance can do excellent work with a simple telescope whose optics consist of a lens or mirror with an eyepiece mounted in a straight tube. On the other hand, the study of astrophysical problems has required more and more additions to such originally simple instruments. We have strapped on them cameras of all sizes, odd shaped spectrographs, photometers, and other auxiliary apparatus of all kinds of description so that large modern telescopes have become quite complicated machines.

That this has made the precise balancing of a telescope somewhat more delicate is not surprising. Many an observer has been embarrassed at times to find that after adding some new attachment to his telescope and balancing it near the meridian the instrument has a tendency to run away from him in other positions. I remember being told once that it was impossible to have a certain large telescope in equilibrium in all positions. A little thought on the mechanics of the problem should dispel such misconceptions.

An equatorially mounted telescope, no matter of what type or size, has always a polar axis and a declination axis at right angles to it. To have the telescope in balance we have to bring the center of gravity of all the moving parts exactly on the polar axis. Only when this condition is satisfied will the instrument be in indifferent equilibrium in all positions, which will insure its safe handling and especially its smooth operation by a driving mechanism compensating for the daily rotation of the earth. If this condition is not satisfied, no matter what distribution of weights holds the telescope in equilibrium in one position, the instrument will be out of balance when pointing in another direction.

The following simple procedure to fulfill the above requirement has been applied by the writer to a great number of telescopes of all sizes and descriptions.

a) First consider the balance around the declination axis. We put the telescope, schematically represented in Fig. 1, in the meridian and point the tube nearly toward the horizon. We adjust the weights until

the instrument moves with the same ease up or down. What have we accomplished thereby? We have brought the center of gravity C of all the parts rotating around the declination axis not necessarily *on* the axis O but only in C somewhere in the vertical plane of that axis. The center of gravity may be below the axis or above it: in fact, finders on one side of the tube, cameras on another, off-axis spectroscopes at the end will make the tube anything but symmetrical in weight distribution. So

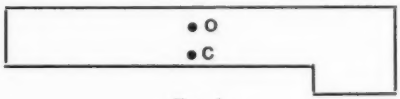


FIG. 1

we have to expect the center of gravity C to be either below O—in which case we have stable equilibrium in the horizontal position—or above O—in which case the telescope would tend to keep moving when once started rotating. But the distance between O and C will be in general too small to distinguish between the two cases when the instrument points to the horizon.

b) The next step is to turn the instrument to the zenith (Fig. 2). Then the center of gravity C will be on a level with O and we will be in the most sensitive position to bring out the lack of coincidence of these two points. We move the telescope gently north and south of the zenith and find out in which direction it drifts most easily: if it moves more readily toward the north we are sure that C is to the south of O. Hence, we have to shift some of our balancing weights from the south to the north but we have to shift them horizontally. This will move C horizontally and a few trials will tell how much weight should be shifted. We cannot just add a weight to the north of the tube because this would lower the center of gravity C below O and disturb our adjustment in position a). This makes it clear that in order to secure perfect balance around the declination axis in all positions it is necessary to make the adjustment first in the horizontal position and next in the vertical position. *Both* positions are necessary and only after balancing has been attained successively in both positions can we be certain that the points C and O coincide and that hence the telescope will remain in indifferent equilibrium wherever we stop it.

FIG. 2

c) Our next concern is the balance around the polar axis. Here again the desired solution requires two positions which are equally essential and no amount of adjusting in the meridian alone will give us the desired result. Suppose again the telescope to be in the meridian: our previous operation has brought the center of gravity of the tube in T on the declination axis TW (Fig. 3). In order to obtain equilibrium around the polar axis PN pointing to the north N, we first need a suf-

ficient counterweight in W at the end of the declination axis opposite to the telescope. By watching the motion of the telescope when we swing it gently around the polar axis a little east or west of the meridian we will be able to adjust the amount or the position of the counterweight

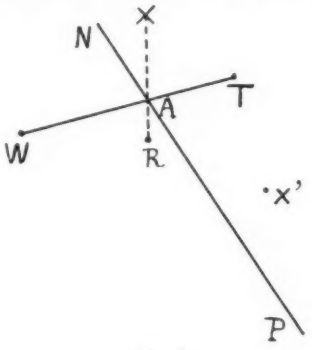


FIG. 3

W so that the instrument is in balance. But again we ask the question, what have we achieved thereby? We have brought the center of gravity of the rotating mechanism in the vertical plane of the polar axis but in this position nothing can tell us if the center of gravity R of the whole rotating system coincides with the polar axis in A. The plane formed by the two axes WT and AP does generally not divide these two axes into symmetrical parts. There are clamping and slow-motion transmissions, especially in larger instruments, also electrical motors, castings, and other mechanical devices which cannot always be built exactly symmetrical in regard to the plane of the two axes. Hence, in general, the center of gravity of the whole mechanism will be in R below or above the intersection A of the axis. Again this situation will produce the effect that, no matter how well the balance is made when the telescope is in the meridian, as soon as we get away from that direction the instrument will no longer move equally well right or left.

d) How can we overcome this? We have to add a weight in X opposite to R relatively to the plane WAP. We will turn the polar axis six hours away from the meridian. Then the plane WAP is vertical and R will be either farthest east or west from that vertical plane. This is the position in which the lack of coincidence of R and A will produce the greatest inequality in the ease of motion of the instrument around the polar axis. By installing a weight in X this inequality can be eliminated completely: if this weight can be installed far from the axis a small amount may suffice. The nearer to the polar axis we have to put it the bigger the weight will have to be. It is evidently not necessary to add this weight on the extension of the line RA. It could be added in

X' or any other point above the axis.

At the 40-inch telescope of the Yerkes Observatory this weight X is represented by a load of nearly 200 pounds at a distance of four feet from the plane WAP. A convenient location for this weight was found on one of the spokes of the declination circle. In the case of the 82-inch telescope of the McDonald Observatory at Fort Davis, Texas, this load is added laterally to the large counterweight in right ascension.

But once more it should be pointed out that for complete balance around the polar axis in all positions it is necessary to check the distribution of the weight successively in two positions of that axis at right angle to each other. Considering both axes, the complete balancing of the instrument therefore will require adjustments in the four special positions of the instrument described in paragraphs a, b, c, and d: first in the meridian, tube horizontal and tube vertical, next in the meridian and six hours away from it. If at all possible it is best to have the telescope pointing to the north pole when the checks are made for the two positions of the polar axis. In that position a slight residual error in the balancing around the declination axis will have a minimum effect on the adjustment around the polar axis.

Modern telescopes provided with ball bearings are quite sensitive to small errors in the balance even though they may weigh many tons. The lack of adjustment of the weights therefore can lead to serious trouble. However, the same remarks apply to a telescope of any size and many a private telescope owner may welcome the use of the above procedure to get rid of the uncomfortable feeling that goes with a telescope out of balance in certain positions.

Recent Light Variations of Mu Cephei

By JOSEPH ASHBROOK

Perhaps more observations of brightness of μ Cephei exist than of any other red irregular variable star. Yet μ Cephei is still in need of continuous observation. Its complex light curve apparently consists of at least two superimposed variations of changing amplitude with cycles of about 730 and 904 days.[1] An underlying period of 13½ years has been suspected.[2] The disentanglement and interpretation of these periodicities will require a continuous light curve of great homogeneity extending over many decades. Furthermore, the value of any study of the spectral changes of this star is enhanced by knowledge of associated changes in total brightness.

A definitive light curve from 1863 to 1938 has been formed by W. Hassenstein.[1] Much care was taken to reduce all observations to one uniform photometric system, whose zero-point was fixed by Hassenstein's photometric measures.

Among the materials for an extension of Hassenstein's light curve is a series of 349 visual estimates made by the author between May, 1935, and August, 1941. These observations were made by the Pickering Interpolation Method, using an opera glass. Magnitudes on the Harvard Photovisual System for the comparison stars were taken from Harvard Mimeogram No. 3. This is probably the most reliable source available for the relative magnitudes of bright stars on a visual scale.

TABLE 1

COMPARISON STARS

	M_{pv}	Spectrum
ζ Cephei	3.42	K0
ϵ Cephei	4.18	F0
ν Cephei	4.31	A2p
λ Cephei	5.11	Od
HD 210855	5.29	F8

The great bulk of the observations were made in terms of ζ and ϵ Cephei. The variable was seen systematically faint when compared with ζ and ν Cephei; such estimates have been corrected by $-0^M.08$. The remaining comparison stars were seldom used. The internal probable error of a single observation is $\pm 0^M.067$.

Corrections for systematic errors depending on hour angle were applied to comparisons with ζ and ϵ Cephei. Grouping the observed magnitudes according to local sidereal time gave the corrections in Table 2. This procedure obviates the need for a separate consideration of the effects of differential atmospheric extinction.

TABLE 2

SYSTEMATIC CORRECTIONS (SMOOTHED) FOR HOUR ANGLE ERRORS

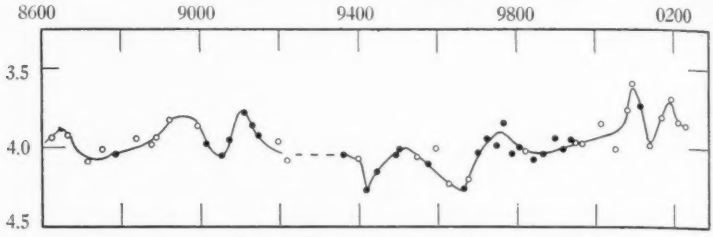
Sid. Time h	Corr'n M	Sid. Time h	Corr'n M	Sid. Time h	Corr'n M
0.5	—0.05	8.5	+0.09	16.5	+0.01
1.5	—0.05	9.5	+0.10	17.5	—0.01
2.5	—0.04	10.5	+0.10	18.5	—0.03
3.5	—0.03	11.5	+0.11	19.5	—0.04
4.5	0.00	12.5	+0.09	20.5	—0.05
5.5	+0.02	13.5	+0.07	21.5	—0.05
6.5	+0.05	14.5	+0.05	22.5	—0.05
7.5	+0.07	15.5	+0.03	23.5	—0.05

The corrected magnitudes were then combined into fortnightly means, given in Table 3.

A control on the resulting light curve may be had by comparison with the photoelectric observations made at Potsdam by Hassenstein,[3] extending to J.D. 2429086. The average difference, Hassenstein — Ashbrook, is $+ 0^M.13$. After allowance for this quantity, the average deviation of the author's normal points from the Potsdam curve is $\pm 0^M.07$; the largest deviations are $+ 0^M.16$ and $-0^M.15$. The larger features of the visual light curve may therefore safely be accepted as real.

The adjoining light curve shows that between 1937 and 1941 μ Cephei underwent small irregular fluctuations of 100 to 400 days duration

around a mean magnitude of 3.99. The extreme range was $0^{M}.68$, from $3^{M}.59$ to $4^{M}.27$. Well marked maxima occurred at J.D. 2429110, 2430090,



LIGHT CURVE OF μ CEPHEI

(Ordinates: Magnitude in Harvard Photovisual System. Abscissae: Julian Days, beginning with J.D. 2,428,600. Dots represent Means of 5 to 20 Observations; Circles 1 to 4.)

and 2430190, minima at 2429430 and 2429660. Possibly the peaks at 2430090 and 2430190 constitute a single broad maximum distorted by minor fluctuations. These epochs show only rather indistinctly the persistence of the 904 day cycle, but the search for periodicities is embarrassed by the comparative quiescence of the star.

TABLE 3

FORTNIGHTLY MEAN MAGNITUDES FOR μ CEPHEI IN THE HARVARD PHOTOVISUAL SYSTEM

J.D.	m_{pv}	n	J.D.	m_{pv}	n
2427341	3.86	4	2429552	4.06	4
55	3.88	4	81	4.11	12
83	4.02	1	95	4.00	2
8034	3.94	5	9629	4.22	3
92	4.22	1	66	4.25	10
8635	3.95	1	80	4.19	2
57	3.88	5	9705	4.03	7
71	3.92	3	28	3.94	7
8722	4.10	4	50	3.98	13
58	4.02	2	71	3.84	9
92	4.05	3	89	4.04	17
8843	3.95	1	9810	3.99	5
79	3.98	3	25	4.02	4
8896	3.94	11	46	4.08	20
8928	3.83	3	74	4.04	14
97	3.87	4	9901	3.93	14
9017	3.98	17	18	4.01	10
61	4.06	8	41	3.94	6
78	3.96	6	55	3.96	4
9116	3.78	8	78	3.97	4
37	3.87	7	2430016	3.84	1
52	3.92	7	54	4.01	2
9200	3.96	3	76	3.83	3
25	4.09	3	94	3.59	2
9365	4.05	6	0113	3.72	6
9402	4.12	3	37	3.96	3
25	4.27	8	69	3.81	4
52	4.15	7	95	3.68	2
97	4.05	6	0215	3.85	2
9507	4.00	9	31	3.87	2

BIBLIOGRAPHY

[1] W. Hassenstein, *Potsdam Pub.*, **29**, No. 1, 1938.

[2] W. Zessewitsch, *N.N.V.S.*, **3**, 8, 1930.

[3] W. Hassenstein, *loc. cit.*, p. 35.

HARVARD COLLEGE OBSERVATORY, CAMBRIDGE, MASSACHUSETTS.

War Work of Astronomers*

By C. C. WYLIE

Astronomy is the most comprehensive of the basic sciences. It includes the application of mathematics and physics, and to a smaller extent of chemistry, to the study of the universe. Astronomy includes the study of the solar system, and hence of the earth as one of the planets. The study of the earth as a planet includes the fundamentals of geology, meteorology, and navigation. An astronomer may publish notes on research in the technical journals of astronomy, mathematics, physics, meteorology, and engineering, for example, and be quoted in still other fields.

Modern warfare is highly technical, requiring the services of mathematicians, physicists, chemists, engineers, meteorologists, and others in the production and testing of war material. The officers on the fighting fronts must include men with good training in mathematics, physics, engineering, meteorology, and navigation. Compare these fields with those in which an astronomer should be trained, as indicated in the preceding paragraph.

A young man with training in astronomy has a good background for several different fields of war work, and can go into any one of these with only a little additional study. To illustrate this, let us consider some of the problems on which astronomers worked during World War I.

The development of the airplane had introduced several new problems. One of these was anti-aircraft guns. The old tables for firing guns at low angles were of no value when firing almost vertically upward, so it was necessary to construct new tables.

To obtain data for constructing these tables, firings with tracer shells were made at proving grounds. They were made using various guns, various muzzle velocities, and various types of shells. Astronomers with experience in plotting the paths of meteors watched the flight of these shells through coordinate systems and recorded the angles. From the angles of the apparent path as recorded by two or more observers, the real path of the shell could be calculated.

In the latter part of World War I, artillery was used with the guns fired at higher angles and to greater distances than heretofore. To hit

*Presented at the Dallas, Texas, meeting of the Section on Astronomy of the American Association for the Advancement of Science, December 30, 1941.

well at these greater distances, it was necessary to calculate more accurately the resistance of the air at various densities, and also the corrections for the effect of winds at various velocities. An astronomer was placed in charge of the American work, with mathematicians, physicists, and other astronomers helping. These men developed new formulas, and constructed new tables, so that the path of the shell could be calculated more accurately, as indicated above.

These same men worked along with Army Ordnance officers on improving the design of shells. The powder charge also was increased, and at the end of the war, the 6-inch (155-mm) gun would hit better at 16 miles than it did at the opening of the war at 8 miles.

In a modern military machine everything must be timed accurately. Soon after the United States entered the war in 1917, the Government placed orders for thousands of time pieces, including pocket watches, stop watches, ship watches, torpedo boat watches, chronometers, and ships' clocks. Several thousand timepieces were ordered for the Navy, and none of these could be accepted until tests showed that they were sufficiently accurate for technical work. Two young astronomers were assigned to this testing.

The regular reading of these timepieces, so that the rates in various positions and at various temperatures could be obtained, was quite a task. Daily comparisons of the watches with a standard clock were made, recording the watch reading to the second. A routine was standardized by which a man working alone made these comparisons at the rate of 540 per hour.

Often a watch or clock was found to be good, excepting that the rate was large. The sending of these to the Navy jewelers for regulation by the usual methods required several days, so a method of quick checking was developed. With no equipment but an accurate watch for comparison, the rate of a watch could be obtained to the tenth of a second per day in less than half an hour. By this method of quick checking, a watch could be regulated closely within a few hours.

Watches were sent by the hundreds to the Bureau of Standards for testing, giving the Bureau an entirely new problem. The methods of rating previously used were too slow. Few college students have had any laboratory work requiring timing with anything other than a stopwatch. The man to whose department the watches were sent secured one astronomer, but another trained person was needed.

Inquiries located a young graduate student in astronomy, who had enlisted before the draft, at one of the training camps in the United States. A letter from the Director of the Bureau of Standards to the War Department resulted in the assignment of this man to the Bureau for the remainder of the war.

The development of the airplane suggested photographing the enemy's positions from the air. Cameras then in use, however, were not well adapted for the work, so experts set about to develop more efficient

lenses and plates. Three men formerly in professional astronomy worked as optical experts in this field.

When Lippershey invented the telescope in 1608, the Dutch government immediately saw its military possibilities and asked that he develop binoculars, or field glasses, so that the officers could use both eyes. At the time of World War I, field glasses were ordered for both the Army and the Navy in great quantities. One of the experts working on the improvement of the lenses for field glasses was a man who had been in professional astronomy.

A difficulty with sudden expansion of a military program is that the routine methods of testing equipment purchased are too slow. As an illustration, great numbers of sextants were ordered in 1917 for the Navy. Certain optical parts of sextants had been tested with a machine manufactured in England, but the large orders made the parts arrive much too fast for this machine. The Commander in charge of the testing assigned a young astronomer to the machine, with instructions to make whatever modifications were necessary to speed up the testing. The young man had the old machine altered and simplified by an instrument maker, and, two or three days after taking charge, he could put the material through about ten times as fast as previously. A second machine was constructed to further speed up the testing, and a lieutenant was instructed in its operation. All this took only about two weeks, after which the young astronomer was returned to his previous technical work, leaving the routine operation of the testing machines to others.

One of the difficulties experienced by the Government in war times is the great flood of inventions submitted, nearly all from people with less training than one should have for work along the line of the invention. This means that the Patent Office, or some office, must have a large staff to look over the plans submitted and sort out the relatively few inventions that really are worthwhile. For this work, men with broad technical training are needed, and at least four working in the Patent Office during World War I had been in professional astronomy.

Because of the importance of mathematics in modern warfare, extra teachers of algebra, trigonometry, and other branches of mathematics are needed in the training camps as well as at Annapolis and West Point. The thorough mathematical training for professional astronomy, means that astronomers can handle this work well. They are familiar with many applications of mathematics, especially to problems of navigation, and this means that they can make their teaching interesting and practical. Some of those teaching mathematics at Annapolis during World War I were men who had been in professional astronomy.

Many problems of modern warfare require an expert knowledge of physics, and most of these problems are handled at the Bureau of Standards. Several men working as physicists at the Bureau of Standards during World War I had been in professional astronomy.

The combat branches of the Army and Navy are regarded by many,

if not most, people as the war work of greatest importance. This brief investigation revealed that astronomers served as officers in the Infantry, in the Artillery, and in the Navy during the World War I. It is interesting that the investigation revealed no one with graduate work in astronomy who was serving as a private at the end of the war. Those with training in astronomy who had not been made commissioned officers were transferred to technical work.

It is too early (December, 1941) to make any summary of the different lines in which astronomers are working in this war, World War II. It appears, however, that professional astronomers are working in nearly all the fields in which they worked during World War I, and some amateurs are doing important optical work. The retiring chairman of the Section on Astronomy of the American Association for the Advancement of Science is unable to give the customary address at the Dallas, Texas, meeting, because he must be in Washington on war work the week of December 28-January 3. One of the papers presented at the Dallas meeting is by a young author who is at one of the air fields in training as a navigator. Other astronomers missed the meeting primarily because of war work.

For astronomers without special qualifications for other war work, the greatest service that can be rendered is continuing in teaching. Because of the number of astronomers, especially among the younger men, who go into other fields of war work, the finding of a sufficient number of qualified teachers for the classes which should be taught in astronomy is a problem.

In time of war, the Army and the Navy both have difficulty in getting enough well-qualified young men for their officer's training schools. The demand for men qualified to enter training for meteorology and navigation regularly exceeds the demand. For both of these fields, astronomy is the basic science, and a better supply of properly trained men could be obtained by advising young men below military age to take mathematics and a good course in descriptive astronomy. In time of war, the astronomy course should stress quick identification of the brighter stars and planets as seen in the sky, the motions of the earth, the astronomical fundamentals of weather and climate, longitude, latitude, and the Sumner line of position. Work beyond that of the standard texts should be given in these fields.

Courses in meteorology and navigation, with plenty of observational and laboratory work, and following the latest methods, are good. Much larger classes, however, can be handled efficiently in general astronomy, and the Army Training Schools make provision for the teaching of meteorology and navigation. The more fundamental and comprehensive course, therefore, should be given preference if any selection is necessary.

University of Iowa, April 17, 1942.

Planet Notes for June, 1942

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from *The American Ephemeris and Nautical Almanac.*

Sun. Apparent positions of the sun for June 1, and July 1, respectively, are: $\alpha = 4^h\ 32^m.9$, $\delta = +21°\ 56'.1$; $\alpha = 6^h\ 37^m.1$, $\delta = +23°\ 10'.2$. The sun moves from the constellation Taurus into the constellation Gemini on June 19. The sun will reach the summer solstice June 22, $1^h\ 17^m$, which instant will inaugurate the season of summer.

Moon. Phenomena of the moon will occur as follows:

		h	m
Last Quarter	June	5	21 26
New Moon		13	21 2
First Quarter		21	20 44
Full Moon		28	12 9
Apogee	June	13	19
Perigee		28	1

Mercury. Mercury will reach inferior conjunction and become a morning star on June 12. By the end of the month the planet will be $1^h\ 25^m$ west of the sun and in declination $+19°$, and may be found in the eastern sky just before sunrise.

Venus. Venus will remain a morning object decreasing elongation during June. By July 1 the planet will be 2½ hours west of the sun. The declination increases from $+9°$ to $+19°$ during June. Data concerning Venus, of interest to observers, are tabulated below:

Date 1942	Distance from Earth in miles	Angular Diameter	Fraction of disk seen illuminated	Stellar Magnitude
May 30	96,919,000	16".1	0.69	—3.6
June 9	103,692,000	15.1	0.73	—3.5
19	110,198,000	14.2	0.76	—3.5
29	116,407,000	13.4	0.79	—3.4

Mars. Mars will be an evening object, with gradually diminishing elongation, during June. On June 1 the planet will be 3^h east of the sun, and in declination $+23°.0$. By July 1, the corresponding data will be, $2^h\ 15^m$ east of the sun, and declination $+18°.8$. It is seen that, due to the northerly declination, the planet will be a conspicuous evening star during the month of June. The apparent motion will be from a point just south of κ Geminorum to a position about 3° east of δ Cancri. The angular diameter of the planet will diminish from 4".3 to 3".9 during June, while the stellar magnitude remains close to +2.0.

Jupiter. Jupiter will be in conjunction with the sun on June 25.

Saturn. Saturn will be situated in the morning sky during June, and by the end of the month may be easily found just before sunrise, being by that time 2¼ hours west of the sun and in declination $+19°.5$.

Uranus. Uranus will be a morning object during June, but rather too close to

the sun for observation. On June 29, 20^h, the planet will be situated 1°.5 north of the planet Venus.

Neptune. Neptune may be located by searching telescopically just east of the bright star, β Virginis. Apparent positions of the planet for June 1 and July 1, respectively, are: $\alpha = 11^h\,51^m.5$, $\delta = +2°\,22'.2$; $\alpha = 11^h\,51^m.9$, $\delta = +2°\,18'.3$. An occultation of Neptune, not visible in the Americas, will occur June 21, the time of conjunction in right ascension being $15^h\,28^m.6$. The occultation will be observable between latitudes 69° N and 7° S. It is of interest that an occultation of β Virginis occurs two hours prior to the occultation of Neptune. The occultation of β Virginis is observable north of latitude 34° N.

Occultation Predictions for June, 1942

Taken from the *American Ephemeris*)

Date 1942	Star	Mag.	Immersion: Greenwich C.T.	Immersion: *a*	Immersion: *b*	Immersion: Angle E from N	Emersion: Greenwich C.T.	Emersion: *a*	Emersion: *b*	Emersion: Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
June 1	130 B.Sgr	6.5	7 29.0	−1.8	−0.1	84	8 44.4	−1.6	−0.7	267
4	151 B.Cap	6.1	9 24.3	−1.9	+0.5	78	10 43.4	−1.5	+0.4	238
19	19 Leo	6.4	2 1.3	−0.4	−0.9	70	2 48.3	+0.3	−2.3	327
19	*R* Leo (Var)		2 4.2	−0.2	−1.5	101	3 2.4	+0.2	−1.7	296
21	80 Leo	6.4	2 39.3	−0.1	−3.1	167	3 16.1	−0.7	−0.6	238
24	623 B.Vir	6.5	4 13.6	−0.9	−2.0	133	5 13.0	−0.6	−1.2	263
26	49 Lib	5.5	3 47.4	−1.5	−1.5	136	4 49.0	−1.5	−0.4	249
27	29 Oph	6.4	3 12.0	..	..	163	3 47.1	..	..	218
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
June 1	130 B.Sgr	6.5	6 54.2	−1.8	+0.6	88	8 12.7	−1.9	0.0	270
4	151 B.Cap	6.1	8 49.0	−1.6	+1.4	71	10 9.5	−1.9	+0.8	252
19	18 Leo	5.9	1 17.5	−1.9	+0.1	58	2 0.2	+0.2	−3.5	346
19	19 Leo	6.4	1 51.4	−0.9	−1.3	94	2 55.3	−0.2	−2.2	308
19	*R* Leo (Var)		2 1.2	−0.6	−1.9	121	3 5.9	−0.3	−1.6	281
22	η Vir	4.0	4 40.2	−0.4	−2.5	151	5 28.6	−0.4	−0.9	252
24	623 B.Vir	6.5	3 58.2	−1.2	−2.2	148	4 57.4	−1.5	−0.8	255
24	95 Vir	5.5	5 7.5	−1.1	−1.5	113	6 15.3	−0.8	−1.6	284
26	49 Lib	5.5	3 26.0	−1.0	−2.0	159	4 13.2	−2.5	+1.1	234
27	90 B.Oph	6.5	1 14.2	−1.4	+1.8	68	2 8.2	−0.7	−0.5	320
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
June 1	130 B.Sgr	6.5	6 15.3	−0.6	+0.3	119	7 16.9	−1.5	+1.4	250
4	151 B.Cap	6.1	8 11.2	−0.6	+1.4	81	9 18.1	−1.1	+1.4	254
17	BD+16°1662	6.1	4 14.3	−0.9	+0.9	40	4 40.1	+1.0	−3.7	348
24	95 Vir	5.5	4 31.7	−1.4	−1.9	145	5 41.0	−2.2	−0.6	264
30	47 B.Cap	6.2	12 54.1	−0.7	+0.6	41	13 51.0	−1.2	−1.6	283

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

War has already had its effect upon the A.M.S. Several of our most active members are known to be in the army or navy, while it is probable that others are who have not notified us of the fact. Also many of the rest who will not be called into military service will be far more occupied than usual with various phases of war work. All of these facts mean fewer reports. In addition, ships have almost ceased reporting fireballs, due to conditions easy to understand. This means the loss of from 100 to 200 reports annually. While I heartily agree that the primary and positive duty of every one of us is to aid our country to the utmost in its fight to save civilization itself, still there are many who will, from various legitimate causes, not be so heavily occupied with war work that they do not have some leisure. To these persons I specially appeal to step in and help fill the gap left by those temporarily forced to give up or curtail their meteor work. There are certainly many such persons if they could only be reached and their interest aroused. In any case, nobody will be so busy that he can not report the one or more fireballs he may see casually in 1942. Also the A.A.V.S.O. members who will be able to keep up their variable star work could give real aid by reporting telescopic meteors. This is always done by a few, but the great majority still cannot be prevailed upon to make the small effort necessary to report the small number they see in the course of a year.

Having fewer current reports to deal with, I have been making an effort to compute the heights, etc., of fireballs, the reports on which have been in our files sometimes for many years. Some of these have been published in recent Meteor Notes and another follows here. I hope to have others ready in the near future. Similar work is being done by Mr. Donald MacRae of our Cook Observatory staff and by Miss Edith Reilly, a graduate student in Astronomy. So 1942 should see a considerable reduction in our unfinished cases from previous years.

A request is made that members keep us better informed of their changes of address. Also I wish to state that the annual dues of all in military service of any kind will be cancelled for the duration of the war, if they will only notify me of the facts.

Fireball of 1913 July 21

After the death of Professor Cleveland Abbe, Sr., a man to whom I was under very deep obligations for valuable assistance and advice in my early work on meteors, several large envelopes filled with papers dealing with this subject were turned over to me. From time to time use has been made of the data found therein. Among other documents are two dozen letters dealing with a brilliant twilight fireball which appeared over central Iowa on 1913 July 21/22 (possibly on July 22/23 or 23/24 as observers are somewhat contradictory as to the date). Professor Abbe had notices put in the Iowa papers and tried through local Weather Bureau stations to get reports. He succeeded in securing 23, but evidently either decided that a solution could not be made or perhaps laid them aside for future work. Meantime one good report came to the A.M.S. When I took up the case some

weeks ago, I wrote to Professor C. C. Wylie for possible data in his possession. He most kindly had an assistant examine files of local Iowa papers published for several days succeeding the fireball's appearance, and as a result three more such reports are available. I am under real obligation to him for this help.

As frequently happens, the first attempts to find the projected path were disheartening, but more study of the reports in all their implications gradually brought a clearer picture. In the end, I have been able to work out a fairly satisfactory path, the greatest value of which is that it forms a basis for the study of the smoke-train which endured for a very long time. This will be discussed later. The azimuth of the path was determined as usual by intersecting lines at each end, but was checked by the perpendicular path from S7, Columbia City. Also, I was assisted by four sets of drawings of the train and its changes of shape. From these, valuable data as to slope and altitudes could be roughly deduced. Finally, I concluded that the azimuth and slope of path—hence the position of the radiant—are pretty well determined and the thing which remains most uncertain is the end height and equally the beginning height, because, in this particular case, I had to determine this latter mostly from drawings and slopes, and while the ΔH would not be affected, a change in height of the end point would equally change that of the beginning point. The unweighted mean of the 5 good altitudes of the end point is 38 km, but for the best 2 is only 19 km. The corresponding beginning heights are 111 km and 92 km. Knowing the propensity of observers to overestimate altitudes, and further knowing that 111 km is rather high for a train to be visible (though here one might doubt if the upper end of the train coincided with the point where the meteor first became visible) one is inclined to choose the lower value. However, as a best approximation to the truth, 30 km and 103 km have been somewhat arbitrarily chosen. The velocity depends upon two estimates of duration, namely 2 and 4.5 seconds, average 3.25 seconds. This obviously has very little weight. The zenith correction is based upon assumed parabolic heliocentric velocity.

Date	1913 July 21/22 8:00 ± 06 P.M., C.S.T.
Sidereal time at end point	235°
Began over	$\lambda = 95°\ 51'$ W; $\phi = 43°\ 05'$ N, at 103 km
Ended over	$\lambda = 94°\ 04'$ W; $\phi = 43°\ 27'$ N, at 30 km
Length of path	166 km
Projected length of path	149 km
Velocity	52 km/sec
Radiant (uncorrected)	$a = 73°$; $h = 26°.3$
Zenith correction	$-\ 8°.3$
Radiant (corrected)	$a = 73°$; $h = 18°.0$ $\alpha = 170°$; $\delta = +1°$

The sun had set not long before the fireball appeared and the western sky was so bright that two observers specifically mention only one "star" was visible and others speak of the bright sky, and that it later became darker. The fireball was red and must have been very brilliant; several speak of its having a definite disc. Had it been dark its light probably would have been equal to that of the quarter Moon. At its end it either actually burst or had a great increase in light. Practically every observer mentions the smoke-train. The lowest estimate for its duration is 5 minutes, the two longest, both from Des Moines, S6 and S16, give 45 and 63 minutes, respectively. The last seems to have been timed not guessed at. S24, Eagle Grove and S3, State Center, also gave 45 minutes. A. F. Gibson at Fairfax, S10, submitted a series of 4 fine drawings; he was far off from and

well to the side of the path. B. F. Klemme at Charles City, S9, submitted a series of 4, with times of each. W. A. Hutton at Des Moines, S16, sent in a set of 5, and Miss B. Robach at Sioux City, S17, sent in one drawing. Unfortunately, none of the three who sent in a series made it clear whether the train as a whole shifted from its first position, or whether only deformations took place. The positive statements of motion, omitting deformations seen by everyone, were as follows: E. W. Kelly, Des Moines, S6, ". . . was apparently stationary for some 25 minutes after which it took on a zigzag course and moved to the N.W." S17 (giving irregular drawing) . . . "This figure remained visible about 10 minutes with scarcely a change of form . . . grew paler. . ." L. Welle, at Pella, S20, ". . . It remained red and straight for a minute and then turned white and curled up." R. M. Salzer at Jackson, Minnesota, S22, ". . . extending 20 feet curling up to about 5 feet. . ." H. Umphry at Crystal Lake, S23, ". . . it was horizontal" (apparently not at first) says a farmer said at first it was almost perpendicular. S16 ". . . gradually drifted out of line the currents of air seemed to carry it northward or rather portions of it. . ." S9, ". . . seemed to drift to the south somewhat from original position. . ." S10 ". . . started to fade from bottom upward . . ." and his drawings show drift to south *if* positions as well as form are meant to be indicated. This is the best set and shows the last stage like a W on end with two sharp vertices to north. While far from consistent, the preponderance of evidence is for a slow drift to the south, but evidently, from the very crooked shape, there were many parallel currents, moving with different velocities. It does seem quite certain that no considerable velocity was attained by any part of the train. The evidence of the drawings indicates, though lacking positive corroborative statements, that the train covered the whole path of the meteor. If so, its upper end had a greater height than usual. It would classify under the general term 'day train' as the sun had so recently set. This train is No. 804 in my recent paper "Long Enduring Meteor Trains." In the von Neissl-Hoffmeister Catalogue there is no fireball radiant determined near this date comparable to that derived for this object.

Mail addressed to the following persons formerly members of the A.M.S. has been returned to our headquarters by the respective postoffices. If anyone knows the present address of any of these men, it would be a favor to communicate the same to me.

Joshua L. Bailey, Jr., Baltimore, Maryland.
Sterling Bunch, Wheatland, Oklahoma.
R. B. Butler, Plainfield, New Jersey.
B. C. Darling, Lansing, Michigan.
G. A. Fentress, El Dorado, Arkansas.
Roland Gillespie, Webster Groves, Missouri.
John E. Lamb, Regina, Saskatchewan, Canada.
Stuart L. O'Bryne, Webster Groves, Missouri.
Dr. Eugene M. Parker, Houston, Texas.
E. F. Ritter, Baltimore, Maryland.
Carl P. Schafer, Nashville, Tennessee
C. H. Travis, Milford, Michigan.

Flower Observatory of the University of Pennsylvania, Upper Darby, Pennsylvania, April 8, 1942.

Meteors and the Lunar Surface

By C. C. WYLIE

In the March, 1942, issue of POPULAR ASTRONOMY, Mr. J. H. Darling calls attention to the fact that textbooks on astronomy do not bring out the connection between the observational evidence that the surface of the moon is covered with a fine dust and the impact of meteors on the moon. We are sending Mr. Darling some extracts from the chapter on the moon in our "Descriptive Astronomy," copyright 1941, a manual published by the ditto process for the use of students at the University of Iowa. Other persons, who have read Mr. Darling's note, may be interested in seeing this material also. The following is from page 168.

"Without an atmosphere, meteors would strike directly and explode, with a force many times that of the explosion of an equal weight of nitroglycerin. The millions of tiny meteors striking each day would have pulverized a layer a few inches thick since the formation of the moon. Studies indicate that the surface of the moon is a fine dust, as would be expected, instead of bare rock." The following is from pages 170-171.

"The fact that the surface of the moon appears to be covered with a fine dust, presumably material pulverized by tiny meteors, should be kept in mind. With such an effect of small meteors apparent, one would expect an effect of large meteors, also.

"From the rate of fall of meteors of all sizes observed on the earth, a curve can be constructed and extended to give the rate of fall of the large, but rare, crater-producing meteors. Using this figure, and the life-time of the earth-moon system, as determined from the uranium-lead ratio of the oldest rocks and of meteorites, the number of crater-producing meteors which would strike an object the size of the moon in its lifetime can be calculated. This number is of the same order as, but a little smaller than, the number of craters on the moon. Since the moon has practically no atmosphere, there would be practically no erosion, and a crater once formed on the moon would last indefinitely, unless obliterated by a later eruption or by a later meteoric fall. The observed number of craters is what one would expect if many had been produced by the impact of great meteors, and a considerable number of volcanic activity when the moon was young."

The figure "a few inches" for the thickness of the layer of dust is based on the calculation of an inch of meteoric material in the course of twenty billion years, as the rate of fall on the earth.* Each meteor would pulverize many times its own weight of surface rock, since a quart of nitroglycerin will blast out about a cubic yard of rock, and the kinetic energy of each meteoric particle would be many times the energy of explosion of an equal amount of nitroglycerin.

The earliest printed statement we recall on meteors eroding the surface of the moon is that in "Meteors" by C. P. Olivier, 1925. It is as follows, "Therefore there must be a continual effect, not unlike erosion, going on, because not only would these projectiles break off sharp edges, when striking at an angle, but

*The figure twenty billion years is the time required for an inch of meteoric material to accumulate at the present rate of fall as indicated by observations. It is not an estimate of the period for which meteors have bombarded the earth. Estimates for this period vary from two billion to five billion years. See *Contribution Number Six of the University of Iowa Observatory*, pages 186-187, or POPULAR ASTRONOMY, February, 1935.

themselves would be fused and carry off a tiny amount of fused material from the rock struck, if they went through it. In any case there would be a small amount of material melted each time and often distributed."

Moulton made very definite statements on the explosive force of the impact of meteors in his book "Astronomy," 1931, and in the chapter on the moon wrote the following. "It is probable, however, as C. P. Olivier has pointed out, that the daily impacts of millions of small meteors throughout countless ages have produced a fine powder which covers the entire lunar surface."

Fath in "Elements of Astronomy," 1934, refers to the evidence for dust, perhaps volcanic, in the following. "Observations by Wilsing and Scheiner on the reflecting power of different parts in comparison with terrestrial rocks show that the dark surfaces of the lunar seas have the reflecting power of various lavas, while the bright parts of crater walls reflect as much light as volcanic ash."

Two more recent texts give the evidence for the lunar surface being covered with dust, but neither makes a clear statement that the impact of meteors would produce a dust including some meteoric material and much more pulverized lunar rock. The following is from "Astronomy" by Duncan, 1935. "Studies of the polarization (page 159) of moonlight by Wright suggest that the reflecting surface is not bare rock but is more probably fine dust perhaps of meteoric or volcanic origin." A fuller statement appears in "Astronomy" by Skilling and Richardson, 1939; but the authors refer to meteoric dust "settling" on the moon, instead of striking the moon with explosive force. The following is a quotation from this book. "A recent study of the moon by F. E. Wright of the Carnegie Institution, and a committee representing various branches of science, has shown that reflection from the moon is polarized in a way which could not be duplicated by any of the substances they tested except pulverized pumice.

"It seems reasonable to suppose that the great and sudden changes of temperature in the moon's rocky crust should in course of time break it into powdered form. Also, meteoric dust settling on the moon has been suggested as a possible explanation of a pulverized surface. Such dust would be similar to pumice. On the earth it is sometimes found staining the perpetual snow of lofty mountains."

Some work, both observational and mathematical, should be done on the possibility of observing the impact of a large meteor on the lunar surface. These meteors would strike the moon with a lower average velocity than the average velocity with which meteors enter the earth's atmosphere. The flash of light from the explosion would be practically instantaneous, instead of the several seconds duration for a spectacular meteor in the earth's atmosphere. The force of the impact of the meteor on the porous, pumice-like lunar surface would carry a spectacular meteor to some depth as it explodes, making the flash of light less conspicuous than one might expect. Perhaps a lunar meteor would need to be about as large as the meteor which struck in Siberia in 1908 to attract the attention of an observer with a modest telescope, and leave him reasonably sure that the flash he had seen was on the lunar surface, instead of something in our own atmosphere. This is a good problem to keep in mind for work after the world conditions become more normal.

University of Iowa, March 31, 1942.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles

President of the Society: LINCOLN LA PAZ, Department of Mathematics, Ohio State University, Columbus

Secretary of the Society: C. H. CLEMINSHAW, Griffith Observatory, Los Angeles, and Department of Astronomy, University of Southern California, Los Angeles

Cataclysm and Evolution

By H. H. NININGER
Colorado Museum of Natural History and American Meteorite Laboratory, Denver

ABSTRACT

Encounters by the Earth with planetoids are here suggested as an explanation of the geological revolutions so often referred to but never explained in geological writings. Such collisions would have been responsible also for the cataclysmic destruction of species, to which Cuvier and his contemporaries gave such great thought.

If, instead of missing our planet by a few hundred thousand miles, the visit of the little planetoid Hermes had been timed slightly differently, a few billion tons of meteoritic matter might have smacked the Earth in a single lump! Mathematicians tell us that a mass of iron, traveling at a speed of only 5 miles per second, would, upon its encounter with the lithosphere, become an explosive having about 4 times the violence of the same tonnage of nitroglycerin! It is difficult to estimate just what would be the effect of exploding a few billion tons of nitroglycerin in the midst of one of the oceans or upon a continent, but it is certain that such an event would constitute a catastrophe of a magnitude never yet witnessed by man. Probably only a few orders of living things would be able to survive the shock on a continent so visited. If an ocean were to receive such an explosive charge, it too would be rendered uninhabitable to great distances from the center of the disturbance, and the resultant tidal waves might prove quite as disastrous to land life on the adjoining continents as if the impact had occurred there.

Historical geologists have always encountered difficulty in explaining certain abrupt breaks in the series of fossil remains that are preserved in the rock formations. Evolutionists, also, have faced the problem of filling in certain yawning gaps in the genealogy of life forms. The "special creationists" of the 18th and 19th centuries took refuge behind very real barriers to the progress of evolutionary doctrines; and, even today, when Darwinism has been supplemented by the discoveries of De Vries, Mendel, and others, the interruptions that are met with in paleontological records constitute a stumbling block almost as serious as they did a century ago.

Historical geologists speak of a succession of revolutions, at the times of which continental masses rapidly rose or subsided. Inundations and sea withdrawals took place. Volcanism on a grand scale is recorded. Drastic climatic

changes also were a part of these revolutions. Alterations, more or less rapid, in the composition of the atmosphere are assumed to have been an accompaniment of evolutionary progress. No one seems to know just what have been the forces back of these recurrent shiftings of the scenery on the geological stage. The stage-hands have kept themselves discreetly "hidden in the wings"!

Astronomers have for a long time been studying planetoids out in the region between the orbits of Mars and Jupiter. More than 1300 of these bodies have been named and described, but, until a few years ago, no planetoid was known to encroach upon the orbit of our planet. Then, within the short space of 6 years, 3 such intruders were seen by astronomers to trespass upon our orbital premises. Since the visit of Hermes, astronomers have begun to realize how easily possible it is for these tiny planetoids to make the rounds of their unknown orbits, reaching well within even our own, and to escape without being seen. Almost none of the host of astronomers who eagerly scanned the sky after the discovery of Hermes had been announced, in October, 1937, was able to locate this nearest known approaching minor planet. The speeding little visitor, after so nearly bumping us, raced away too fast for them to catch up with it; tho it was well within the range of telescopes, as accidental photographs later showed, its apparent rate of movement (due to its nearness) caused it to elude all of its pursuers!

No planned search has ever been made for others of this type of closely-approaching planetoids. All 3 of those so far listed were discovered by accident. In the light of these now known facts, it is difficult to escape the conclusion that there must be many more of them; and, with the interest now taken in the problem, we may confidently expect new discoveries from time to time. Certain leading astronomers have estimated that there may be hundreds of these little bodies which from time to time encroach upon our domain.

Meteorite craters are now an accepted feature of the Earth's topography. While those that have been discovered are small in comparison with what would result were a body of the magnitude of Hermes (estimated to have a diameter of 2000 to 3000 feet) to collide with us, yet it is not at all improbable that the Earth bears many scars of far greater dimensions than the largest known meteorite craters. Ten chances to one, these scars are concealed by water, jungle, desert, or arctic wastes, so that civilized man has never come upon them. This conclusion is reached on the assumption that they have been produced so recently that, had they been on land, the forces of erosion would not yet have erased them. There are of course a thousand chances to one that all of the encounters occurred too long ago for the scars to be preserved down to date.

It seems that we have here an adequate explanation of those successive revolutionary movements in the Earth's crust that are so generally recognized as having taken place, and also of the sudden blotting out of the fauna and flora of certain great areas which the fossil records suggest. The readjustments necessary to the Earth's absorption of such shocks would have involved continental movements of magnitudes varying with the sizes of the colliding bodies. If the dimensions of the lunar craters are to be taken as any indication of the sizes of the bodies that the Earth has encountered, then there must have occurred great changes in the shore-lines, the elevation and depression of extensive areas, the disappearance of low-lying land masses, the creation of islands, the extension and withdrawal of seas, as well as widespread and protracted volcanism. Violent climatic changes would have resulted, locally at least, from the heat of the impacts and from

changes in the content of the atmosphere. More general changes might have resulted from a possible shifting of the poles, in the cases of the largest impacts. These changes would have necessitated faunal and floral readjustments. Species would have disappeared and new ones would have developed to take their places. Changes in geographical range would have brought about new adaptations, and we should expect, in general, just those breaks in the series that are actually found in the rocks.

The Great Siberian Meteorite of 1908: Possibly a Comet that Struck the Earth (Review)

Bearing the title, "The Great Siberian Meteorite of 1908," an article by Mr. William H. Christie of the Mount Wilson Observatory of the Carnegie Institution of Washington, Pasadena, California, appears in *The Griffith Observer* (the organ of the Griffith Observatory, Los Angeles) for April, 1942 (**6**, No. 4, 38-47).* The article is accompanied by 7 illustrations, of which 2 are line diagrams and 5 are photographs, the front cover of the issue featuring an aerial view of the great Arizona Meteorite Crater. Mr. Christie writes: "The following account has been derived, for the most part, from data scattered throughout various publications, especially the translations from the Russian by La Paz and Wiens [published in Vols. 1 and 2 of *C.S.R.M.*], but for some of it I am indebted to the Soviet Government who also provided me with the photographs here used."

Questions are often asked as to whether any meteoritic material has ever been recovered from the site of this most remarkable fall of recent times and what was the nature of the cosmic invader. The following excerpts from the article (it is believed) contain plausible answers to these inquiries.

"A further compilation of data was made by the geologist Obruchev who conducted a geological survey on the Podkamennya Tunguska in 1924. Obruchev also prepared a map of the region from information gleaned from the native Tunguses. The Tunguses, when they were closely questioned on the subject, denied that the meteorite had fallen to Earth and they would agree only to conduct a party to the region of the devasted forest which they had described. This reluctance on their part may be attributed either to superstition, for a legend had already come into being about the descent to Earth of Ogda, the god of fire; or else it may have been fear of punishment for removing the 'glistening white metal' which some of them later admitted having found. Perhaps these fragments were venerated by them as a token of the god, and the relics were too precious to give up.

* * * *

"It is unfortunate that no fragments of the meteorite have been found. Some of the natives report having picked [up] chunks of shiny, white metal as big as one's fist, but none of these have been seen by the investigators. Any that now lie on the surface are effectively hidden by the mosses and shrubs that have since grown up. The only discoveries so far made have been the finding of minute globules of malleable nickelous iron in the sediments dredged from the bottom of the craters and a blistery piece of semi-transparent bluish glass found in one of the clayey sides of a pit. This is, in all probability, a tektite. Kulik believes

*The Secretary reports that a complimentary copy of this issue has been sent each member of the Society.

that the main masses of the meteorite weighed thousands of tons and that they lie buried at a depth of 25 to 50 yards.

"At first thought the report of the finding of glistening white metal might be questioned, because metallic meteorites are usually oxidized when found. The explanation of this anomaly may be that, in the case of the Tungus meteorites, they were surrounded up to the time of impact by an envelope of incandescent metallic vapors and that they were probably further protected during the initial cooling period by a local lack of oxygen. Certainly, if they had cooled from an incandescent state in the presence of oxygen, we should have no shining white metal.

* * * *

"One of the most significant of the phenomena occasioned by the fall of the meteor[ite] was the brilliant sky glows which were observed in many parts of Europe and the British Isles on the night of June 30, and several succeeding nights. The sky was suffused with a reddish hue varying from a pink to an Indian red. Blues and greens were also reported. No flickering or scintillation was observed, nor was there any tendency to the formation of arcs or streamers characteristic of aurorae. A special feature of the phenomena was the extension of the twilight almost to the following daybreak. So bright were these glows that it was possible to read newsprint at midnight without the aid of any other light. In some parts of Scotland farmers were able to work all night getting in their hay before an impending storm broke. (This might be termed 'making hay while the Sun shines'!)

"Many observers thought the glows to be auroral, but the spectroscope failed to show the characteristic lines in the spectrum. Only one observer, as far as I am aware, hit on the cause of the glows. He was Professor Kohl of the Carina Observatory in Denmark. Kohl suggested that the solar illumination of cometary dust high in our atmosphere might account for the glows and directed attention to the fact that several very large meteors had been recently observed.

"The night glows, I think, remove all doubt as to the nature of the object which struck the Earth. It was, apparently, a small comet moving close to the plane of the ecliptic, and the tail, or part of it, which was captured by the Earth, formed the glows.

"The Greenwich time of the collision was $0^h\ 16^m$—just past midnight—hence no glows were observed much west of Greenwich because this hemisphere would be on the side away from the comet. No light phenomena would be visible to the east of the point of fall, because the comet's tail would be pointing away from the Sun—that is, from east to west.

"This, then, appears to be the only recorded instance of the collision of the Earth with a comet. True, it was a very small comet, as comets go, and perhaps many such objects have struck the Earth in the past. The Meteor[ite] Crater in Arizona may be the grave of a similar but much larger body. How long we will have to wait for another such visitor we do not know, but let us hope it again chooses a sparsely inhabited region of this globe of ours for its final resting place!"

On p. 46 is presented a figure illustrating this "Suggested explanation of what happened on June 30, 1908. The head of the comet landed in Siberia and the dust in its tail produced the brilliant sky glows which were observed in Europe and the British Isles."—F.C.L.

The Bucyrus (Ohio) Meteorite Hoax

One of the classic examples of a scientific hoax, of which there are many, that might rank with the famous "Cardiff Giant," the story of "Atlantis" and other similar yarns, which throughout the years, have for one reason or another, been perpetrated alike upon a gullible public and unsuspecting scientists, both pseudo and real, is the persistent report, which keeps bobbing up perenially, that, "in 1875, a man residing in Crawford County, Ohio, was struck and killed by a meteorite."

All who are familiar with the literature of meteoritics must know that the statement is frequently made by our chief authorities, that in so far as is known, "no human being has ever in modern times been killed or injured by a direct hit of a falling meteorite." Ancient history reveals a number of instances where it is related that people were actually killed by meteorites, none of which, however, owing to the remote period of the occurrence and to the nature of the evidence, have ever been wholly substantiated. For example, quoting Humbolt's "Cosmos," we read, "in 616 A. D., a stone fell shattering a cart and killing ten men." Be this fact or fable, we shall never know,—but, so far as its ever being actual scientific data is concerned, we may be quite sure that it is out.

Imagine, then, my complete surprise, when a few years ago, while perusing an old issue of "Minerals" magazine, (Vol. 1., No. 6; June 1892, pg. 182) edited by W. M. Goldthwaite, upon reading from a copied contribution to the *Philadelphia Press* this item:—"To the writer's certain knowledge, there is but one case on record where a human being has been killed by an aerolite or fall of meteoric stone. The fatality mentioned, occurred in Whetstone Township, Crawford County, Ohio, in 1875, and is recorded in the Bucyrus *Journal* as follows:—

"As David Misenthaler, the famous stockman of Whetstone Township, was driving his cows to the barn about daylight this morning, he was struck by an aerolite and instantly killed. . . It appears as if the stone had come down from a direction a little west of south, striking the man just under the right shoulder, passing obliquely through him, from the right shoulder to just above the left hip, burying the greater portion of his body under itself in the soft earth. The stone was about the size of a wooden water bucket, and appears to be composed of pyrites of iron."

Naturally, my first impulse was to take an early train to Bucyrus to investigate what on the surface appeared to be a most startling discovery. This being impracticable at the moment, I decided to wait and think matters over. On again reading the article, the thought came to me,—how could so important an affair taken place in such comparatively recent times, in an old and well established community like Ohio, and yet so completely have escaped the attention of all those working in this particular field of research? As time permitted I undertook a more critical analysis of the various aspects of the story, in the light of what I knew about meteorites, to learn if possible, if there were any weak points about it.

After making due and generous allowances for such errors in reporting as might be attributable to any ignorance of the subject which would be expected of those doing the reporting, I soon came to the conclusion that it would require no Sherlock Holmes to discover and point out several flaws in the narrative of sufficient importance to create enough skepticism concerning its veracity, to eliminate

any probability of its ever having occurred. I shall refer only to a few of the more obvious ones. The reader may see others equally apparent.

In the first place, while meteorite interiors may possibly appear metallic, few have ever been found which might be mistaken for pyrite, even by a novice. Secondly, the angle of strike of a heavy meteorite coming well under control of the Earth's gravity is so near the vertical, (seldom more than 10° to 12° from straight down), that it would have been impossible for it to have penetrated the victim so obliquely as described. This would have required an angle of from 30° to 40°, which is beyond the realm of probability. Thirdly, any meteorite the size of water bucket striking the body of a man in the way described would not have passed through it in so clean cut a manner, but would probably have dismembered the body entirely. Fourthly, if the meteorite had passed entirely through the body, coming out above the left hip, how could it have buried most of the victim under it in the soft ground.

There are yet other questions which might be raised, which are more or less indirectly related to the problem, such as:—why was no part of the meteorite, so important an object itself, ever preserved or more completely described in the scientific literature of the times; and why were some of the more spectacular phenomena connected with the fall, such as sound, light, fumes, etc., not described, or at least mentioned in the report. Also, how would it have been possible, in those "horse and buggy days," without the use of automobiles or telephones, for such an event to happen in the morning, and the news of it be spread, investigated, written up, set into type, made up and published in a country newspaper, in a single day. Furthermore, there seems to be no record existing showing that anyone by the name of David Misenthaler ever resided in Crawford County, and it seems highly improbable that any man listed as a prominent stock-man, in Whetstone Township not far from the County-seat, should be so completely lost sight of. Perhaps, the author of the story knowing the whetstone to have long been the proverbial prize bestowed upon liars of unusual ability, intended that this itself should be the clue, revealing the preposterous nature of the hoax itself.

Now that we have proven, circumstantially at least, the unlikelihood of this event ever having taken place, should any one ever come along later and prove that it did, then I have certainly put myself in a hole. Not being entirely satisfied with so indirect a method of solution, I finally obtained through correspondence, a version of the incident from Mr. James Hopley, who was once the editor of the local paper, as was his father before him, and who is considered one of the best authorities on local history, now available in Crawford County.

Mr. Hopley writes, "This is a story that bobs up quite frequently. I remember the story having appeared in the *Journal*, and probably it was published on April 1. Newspapers used to publish improbable stories on April 1, (all-fools day) and I believe this was one of them. I remember several stories about that period that were similarly fanciful. So far as I have been able to learn there was no David Misenthaler in Crawford County. The story as published in the middle seventies was widely copied and some years ago Professor La Paz, who has been a student of meteors, came to Bucyrus to investigate this story. We talked the matter over and he concluded with me that the story was purely a hoax. That's about all I can tell you of the matter."

Now that we have made our investigation a matter of record, should it ever again come to the attention of this or future generations, they will have the low-

down' on the story and its origin as a matter of reference. The hoax is now properly nailed down, as all good hoaxes deserve to be, lest they become too confusing to unsuspecting scientific investigators working in the far distant future.

BEN HUR WILSON.

Joliet Astronomical Society, Joliet, Illinois.
April 14, 1942.

The Daylight Meteor of April 2, 1942

A daylight detonating meteor was observed in the region of Southern Wisconsin at 5:55 P.M. Central War Time on the second of April, 1942. The explosion was heard over a wide area which included the cities of Beloit, Janesville, and Williams Bay, in Wisconsin and in Illinois as far as the Chicago North Shore. The flash was seen by a number of people scattered from Kings, Illinois, to Mattoon, Wisconsin, over 200 miles north.

Early evidence indicates that it became visible above a point near the Illinois-Wisconsin state line a few miles east of Beloit, and burst and disappeared in the general area of Elkhorn north of Yerkes Observatory. The sky was overcast in the area above which the explosion occurred.

In Beloit the explosion was heard about three minutes after the meteor was seen. A student saw the flash and noted the time on her wrist watch, while a Beloit physician similarly timed the sound of the explosion. Nearly everyone in the Beloit area heard the noise, which to the writer sounded much like the explosion of a charge of dynamite—short and sharp. At least four members of the Beloit College faculty went to their basements to see if their oil-burners had exploded. Many other residents of Beloit and Janesville called the police, thinking that some accident or sabotage had occurred in one of the war industries in the area.

The duration of the flash was short—perhaps a second or two at the most—but the intensity must have been fairly high. One student in the University of Wisconsin in Madison saw it through a hazy sky, to the amusement of his companions. An art student in Beloit noticed a flash on her canvas from a north window above and to the east of her easel.

An observer in Belvidere, Illinois, reported that the meteor disappeared in a shower of sparks, and all observers agree that it disintegrated or disappeared while still well above the horizon.

The writer is collecting as much information about the object as he can find, and expects to make an analysis of it with the aid of some of his students.

RALPH C. HUFFER.

Beloit College, Beloit, Wisconsin.

Comet Notes

By G. VAN BIESBROECK

The rapidly moving object mentioned on p. 231 should perhaps be included under this heading. Only two additional photographic observations have been published, namely the following approximate measures:

	h	m	s	°	′
1942 Mar. 18.22708	11	12	45	+11	41.0
19.25591	11	15	3	+13	24.5

obtained at Flagstaff by H. L. Giclas. In communicating these data Professor V. E. Slipher adds that on both plates the images are not stellar but are somewhat diffuse and have the appearance of comet trails. Delays in transmitting the information and bad weather have interfered with the search at Williams Bay. It is to be hoped that further observations will become available so as to settle the real nature of this object, whose fast motion indicates close approach to the earth.

Only one known comet remains in reach of small instruments at this time: that is COMET 1942*a* (WHIPPLE) which follows closely the course indicated by the ephemeris on p. 224. It is, however, gradually moving into the western sky and before long it will be difficult to follow further. In March there have been more changes in the faint tail that was mentioned last month. A fairly long exposure on March 19 did not show even a trace of its presence. The main broad tail has remained bright with little change in appearance.

PERIODIC COMET SCHWASSMANN-WACHMANN (2) is still under observation in the constellation of Cancer but it is only accessible to larger telescopes.

The expected PERIODIC COMET GRIGG-SKJELLERUP is evidently quite faint yet. On April 4 I ascertained that there was nothing brighter than 16th magnitude in the ephemeris position. However, is is probable that the object will become observable before the end of this month. The ephemeris by F. R. Cripps is continued here from p. 224:

		α		δ	
		h	m	°	′
1942	May 9	7	9.0	+11	36.2
	17	7	37.4	15	4.3
	25	8	11.3	19	32.3
	June 2	8	53.3	25	14.7
	10	9	48.6	31	53.8
	18	11	2.5	38	12.4
	26	12	33.3	41	39.1
	July 4	14	3.7	+40	36.7

It indicates that the comet, which comes to perihelion on May 23, will be located favorably during the coming months.

Two other periodic comets are expected before long: COMET 1929 II (FORBES) and COMET WOLF (1). The first one, discovered in 1929, failed to be observed in 1935 when it was unfavorably situated. Its present location makes it best available for southern observers in the morning sky. The second one has been recorded at all its returns since its first discovery by Max Wolf in 1884 and its motion has been studied with great care by M. Kamienski. It is now a morning object but will probably not be recovered until this summer.

NOTE ADDED ON APRIL 13, 1942

PERIODIC COMET GRIGG-SKJELLERUP was located on a pair of plates exposed by the writer after sunset on April 10. It appeared as a round nebulosity some 15″ in diameter, slightly condensed centrally and of a brightness corresponding to a star of magnitude 15.5. It was found very close to the position predicted by F. R. Cripps in the *Handbook of the British Astronomical Association for 1942:*

1942 April 11.11105 U.T. $5^h\ 56^m\ 31^s06$ $+3°\ 47'\ 54''4$

which shows that the time of perihelion is correct within a couple of hours. The above ephemeris therefore will require hardly any change.

Williams Bay, Wisconsin, April 10, 1942.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Absolute Magnitudes and Space Motions of Long-Period Variables: One of the most important contributions to the problem of the long-period variables is the recent discussion by R. E. Wilson and P. W. Merrill of the Mount Wilson Observatory, in the March issue of the *Astrophysical Journal.*

This paper, the result of the study of radial velocities and proper motions of the Me and Se stars, gives us very useful information on their motions in space and their mean absolute magnitudes. The authors find that although the mean absolute visual magnitudes ($\overline{M}$) for each Me and Se type as a whole averages -1.0, there are certain systematic effects to be found within the groups themselves. For example, three of the elements of motion—the angular and linear peculiar motions, and the linear group-motion—appear to increase with the increase in period, and for the Me stars, the increase is correlated with an advance in spectral subtype. These correlations, combined with the parallactic motion, show that the absolute magnitudes are correlated both with spectral type and with period.

The mean absolute visual magnitude at maximum of the Me stars decreases approximately in a linear form over a range of three magnitudes, from -2.7 for early type (M1e) to 0.3 for late (M8e) stars. If we include the Se stars, we find what is perhaps a more fundamental relation between luminosity and period. Here we find that absolute brightness is at a maximum at -2.7 for intermediate periods—around 175 days—falling off to $\overline{M} = -2.2$ at 150 days and to $\overline{M} = +0.6$ for stars with periods around 450 days. A plot of the $\overline{M}$ values for different periods forms a useful period-luminosity relation for long-period variables of types Me and Se.

The space motions show correlations with type and with period. The mean velocity is 74 km/sec, which is considered high for giant stars. The authors find that, as for other high-speed stars, the apices of motion lie predominantly opposite to the apex of solar motion, and to the direction of galactic motion. The group-motion referred to the sun is in the same direction as for that of non-variable K5 to M stars and for that of the stars of all types with equally large dispersion in velocity. When the group-motion is referred to the centroid of the stars under consideration, that motion is practically at right angles to the direction of the galactic center and opposite that point in the sky toward which the stars in the neighborhood of the sun are approaching in their galactic orbits. Here the preferential motion is in the same direction as that of the stars in general.

Because of their large velocity dispersion, the motions of the long-period variables can be reasonably explained on the basis of galactic rotation. But the correlations between high velocity and period of variation present a difficult evolutionary problem.

The paper is based on a study of 173 variables covering periods from 91 days for T Centauri to 612 days for S Cassiopeiae, and a spectral range from M1e to M8e, with some of Se. The range in mean apparent visual magnitude at maximum is from 3.4, for *o* Ceti, to 10.3, for U Puppis.

All types of light curves are to be found for these variables, including the sine-curve form for many of those of shorter period, through the broad-maximum and narrow-minimum type, to the rapidly rising, sharply defined maximum and broad flat minimum. It would be of interest to correlate the absolute magnitudes with types of mean light curves.

Periods of Variable Stars in the Globular Cluster Messier 3: Probably the last astronomical communication to come from Lembang, Java, for some time is the paper by W. C. Martin, also published in the March *Astrophysical Journal,* on the search for secular changes of the periods of cluster-type variables in globular clusters. In 1938 Martin published a paper on the secular changes of periods of this type of variables in ω Centauri, when he found a marked tendency for the 68 variables there studied to increase in period with time.

Martin's most recent study of the variables in Messier 3 shows little, if any, tendency for those variables to increase systematically in period for the nearly half century over which the observations were made. His data extended from 1895, with the observations made by Bailey, who was the first to note the variations in light of stars in globular clusters, through the 1921 observations by Larink, the 1925 observations by Müller, and in 1926 those by Slavenas and Greenstein, to Martin's own observations in 1940. Three epochs of observations were discussed, 1898, 1921-26, and 1940. For 79 variables of types a or b, out of a total of 98, the value of β—secular change in period—could thus be determined. For the other 19 variables of a or b type, there were found to be irregular changes in period. The periods were found subject to more or less abrupt changes and a remarkable percentage of these irregular changes reached a maximum near the well-known gap in the distribution of period.

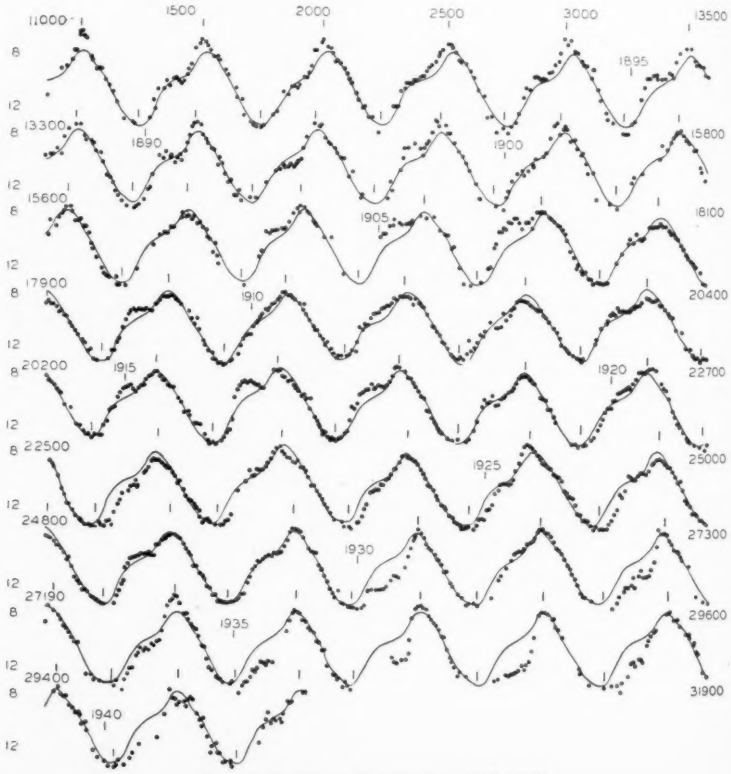
Irregularities in the Observed Light Curve of R Aurigae—1889-1942: In deriving the mean light curves of long-period variables from observations extending over the past twenty years, one is immediately struck with the remarkable differences in form of the individual light curves of the well-known and well-observed variable star, R Aurigae. The same cannot be said for the majority of long-period variables, although we do find minor departures from uniformity for many of them. As a rule, individual curves for the same variable follow the same general pattern.

When the observations—in the form of ten-day means—of R Aurigae were plotted, it was noted that there appeared to be a tendency for the later minima to become broader, whereas in the earlier cycles the minima were consistently narrow. If we read off the width of the curves at the mean median magnitude, 10.5 I to D and 10.5 D to I, we find that the width across minimum in the early years averaged about 200 days, while the width of maxima averaged about 250 days. In later years the width of minima increased to over 300 days, while the width of

maxima decreased to about 160 days. The change appears to have taken place about the year 1927.

This fact led to the idea of carrying the observations back to still earlier years, and accordingly ten-day means were derived for observations made during the past half century. The early Harvard observations were begun in 1889, and these, together with a splendid series made by C. E. Peek at the same time, provided excellent material for discussion. An unbroken series of observations was also made by the B.A.A., dating from 1900 to 1930, and these served to augment those made by the A.A.V.S.O. In all, about 7900 observations have been used in this discussion; these were made in 1566 ten-day intervals out of a possible 1940 intervals. Thus a very continuous and dependable light curve could be constructed.

In practically every cycle, R Aurigae presents a still-stand, or point of inflection, on the increase to maximum, sometimes soon after minimum phase, at other times nearer to maximum phase. This point of inflection is well shown in the mean light curves, thus giving proof of its reality.



LIGHT CURVE OF R AURIGAE, 1889-1942

An examination of the curve shown in the figure clearly indicates the varying form of light curve. The individual ten-day means are shown as dots, and through these points the mean light curve has been drawn, arbitrarily adjusted in time for each cycle. The departures from normality are thus clearly evident. It will be noted that the mean light curve actually coincides with relatively few individual curves.

There is evidence of a small cyclical change in period. This fact is shown by noting how the points indicating observed maximum and minimum phases veer from a straight line when passing from one row of curves to another. Also, it is of interest to note that there is much less deviation from the form of the mean light curve on the descending branch of the observed curve than on the ascending branch. In other words, it would appear that the irregularity in form of light curve occurs following minimum phase rather than after maximum phase has been reached. This feature has also been found to exist for the SS Cygni and R Coronae-type stars.

Contrary to what is found for the B-type light curves—*o* Ceti, χ Cygni, etc.—the variation in heights of maximum for R Aurigae is not very large.

The average deviation of the times of maximum on the basis of a period of 458 days is $\pm 8^d.5$; for minima, $\pm 10^d.0$; for the $10^M.5$ D phases, $\pm 13^d.8$, and for the $10^M.5$ phase, $30^d.7$; thus showing in another way how erratic is the time of arrival at the median magnitude on the rise from minimum to maximum.

R Aurigae is certainly a long-period variable which merits further detailed observation and investigation.

Observers and Observations: U Geminorum was at maximum, long type, early in March, the first actually observed in more than a year. SS Aurigae was observed at maximum late in February, and a few desultory observations show that SS Cygni was on the decrease from maximum about March 20.

Reports from the following observers were received during March, 1942:

Observer	Var.	Est.	Observer	Var.	Est.
Bappu	38	122	Manlin	45	54
Blunck	19	21	Maupomé	43	46
Bouton	22	28	Millard	23	25
Cilley	85	150	Nadeau	29	45
Cousins	20	42	Palo	7	7
Dafter, Mrs.	10	20	Parker	12	12
Fernald	138	240	Parks	31	58
Griffin	42	42	Peltier	93	107
Harris	35	36	Petzold	14	14
Hartmann	103	177	Rosebrugh	5	13
Holt	118	203	Sill	5	5
Houghton	77	193	Topham	8	8
Howarth	15	24	Vohman	6	6
Kearons, Mrs.	69	123	Webb	7	7
Kelly	8	10	Weber	57	61
deKock	53	176	—		—
Koons	26	26	32	Totals	2021

April 14, 1942.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

What Makes the Earth Rotate?

This contribution is another on the general subject of neglected principles of mechanics of solar bodies, one of which appeared in POPULAR ASTRONOMY in February, 1941. In contributions in the August-September issue of 1934 and the April issue of 1938 of this magazine, I showed that the reason the moon presents one face toward the earth at all times and "rotates" like an apple on a stick is because it is forced to do so by the differential gravitation of the earth.

There is not a heavenly body known to be "rotating" in any other way, unless it has a satellite. Mercury, Venus, all the moons of other planets that have marks to disclose rotation, are examples. It would be an anomaly, a violation of well-known mechanical principles (but principles not applied by scientists) if they failed to do just this.

The facts of the preceding two paragraphs are cited by astronomers as peculiar and held to be of no consequence whatever. Highly rated authorities pass it over as being merely the result of gradual slowing down of the moon's original rapid rotation until it equaled precisely the time of its revolution about the earth. Why does it not slow down some more and obey the law of inertia that would orient any plane through its axis in a constant direction in space? The reason is that the earth forces this single rotation in a revolution, and the only way in which inertia enters is to keep that rotation constant, the average of the earth's angular movement in its course.

Another fact of observation is that every heavenly body that has one or more satellites is rotating in the same sense as the satellite or satellites revolve about the primary. And, in general, the more satellites there are the more rapid the rotation. Here again astronomers pass over these facts as merely of interest, if, indeed, they comment at all upon them.

It is well known that the action in the earth-moon system is not one in which the moon revolves about the center of the earth, but one in which earth and moon revolve about the common center of mass of the two bodies, an axis about 1,050 miles within the body of the earth.

Someone may pose the question: If the earth holds the moon with one face toward itself, why does not the moon reciprocate and hold the earth with one face toward itself? This would give us nice long days of something like 670 hours each, 335 hours of night, long enough to freeze the very atmosphere into snow; as in the moon itself; no tides, if, indeed, there would be any ocean; all the lakes and seas frozen into snow "craters," like those in the moon; in fact no possibility of life of any kind on our planet. One condition could be worse, and this is for our planet to have no moon and in consequence no day and night and no seasons.

It is significant to point out here that the Bible, that book that even believing scientists say was not intended to teach science, tells us that He made the moon to

rule by night, also He ordained the moon for seasons.

If the moon's velocity about the earth were exactly that required to preserve a constant distance between earth and moon, in other words, if its orbit were exactly circular, the earth would probably present always the same face toward the moon, though the sun's influence might unbalance this condition. Strange as it seems that little accident, the elliptical orbit of the moon, has so cogent an influence on life on the earth.

In the contribution cited in the first paragraph I showed that the resultant of centrifugal force and gravitation on the moon is equal to two opposing forces, one on the far hemisphere directly away from the earth and the other on the near hemisphere toward the earth. These forces hold one face of the moon toward the earth. Similar forces exerted on the earth compel it to make at least one rotation in a revolution, but the conditions in the case of satellite and primary are not identical.

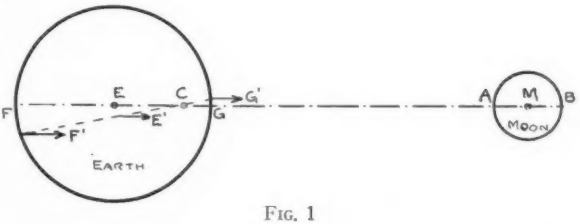


FIG. 1

In the figure suppose the moon were a body free to rotate about M, free for the time from gravitational influence, revolving on an arm CM, and rotating at exactly the same rate on its axis inertia alone assumed to be acting to maintain this condition. Now suppose the revolution on the arm CM were suddenly checked, inertia or momentum of the *revolution* on particle B would be greater than on particle A. In fact the entire hemisphere on the side of B would have greater positive inertia tending to augment the rotation than the inertia on the side of A which tends to decrease that rotation. The effect then of sudden checking of the revolution on the arm CM is to increase the speed of rotation of the moon.

Instead of a sudden checking of the revolution suppose there were merely a retarding due to slower revolution, there would be an increase in the rotation. Conversely, if there were an acceleration there would be a tendency to retard the rotation.

When we revert to the earth-moon system we see that there are periods when there is a retardation in the revolution and others when there is an acceleration in the same. Approach to apogee retards the angular motion of the moon, and approach to perigee accelerates it. These, however, because of the long arm CM, would have inconsiderable influence on the rate of rotation on the moon, since there is a very small relative difference between CA and CB, also because of the ever-present and potent forces, already referred to, that hold one face of the moon toward the earth.

The case of the earth, on the other end of the arm, is quite different. The arm in this case, instead of being hundreds of thousands of miles in length, is only about 3,000 miles long. Furthermore, retardation of revolution of the earth

around C urges both particles F and G into rotation in the same sense, and the very great predominance of the forces of inertia is to quicken the rotation of the earth. This will happen as the moon approaches apogee.

As the moon approaches perigee two opposing tendencies will come into action. The accelerated revolution (angular) will tend to reduce angular rotation in the earth, but the very same acceleration will tend to increase the speed of rotation by the action of the differential gravitational forces. These forces are positive and would doubtless predominate.

Given any slight increase in the revolution or rotation of the earth a third influence is set up. This is the rotating pull of the moon's gravitation on the earth's center (the force E′) and the predominating pull F′ over G′ (considered as protuberances) due to differential gravitation; for while the moon would tend to turn the earth in a revolutionary sense the real effect is rotational, increasing the earth's rotation on its axis.

In addition to the tendency to increase the rotation of the earth any fluid on or near its equator will be urged in an eastern direction by inertia and the forces already described. This is the reason why the earth's upper atmosphere is constantly moving at hurricane velocity in an eastern direction in the tropical belt, as discovered in 1883 when Krakatoa erupted and sent dust into the "stratosphere." It is the reason why the equatorial belt of the sun, of Jupiter, of Saturn, are moving at a greater angular rate than the rate of rotation of these bodies themselves, another fact that does not seem to give astronomers any particular concern.

The facts just stated are the unanswerable argument proving that some force or set of forces outside of planets and sun are compelling these bodies to rotate, otherwise excess rotation at the equators could not possibly be accounted for. The outside forces are supplied by the satellites.

The force compelling the earth to rotate, supplied by the moon, is an accelerating force. If it were not for tidal friction (in fact opposition) the rate of rotation would increase. Tidal friction is considered by authorities of small moment. Many centuries, according to these authorities, would be required to reduce the length of a day by a second or so. This notion is born of the belief that the tide wave is nothing more nor less than a "shape" moving across the ocean. The fact is that the tide wave is the equivalent of a gigantic flow of water moving across the great oceans every 12½ hours at a velocity of 1,000 miles an hour and surging against the eastern shores of all continents, thus working directly against the earth's rotation.

Incidentally, G. H. Darwin's idea that because work is done by the moon in raising the tide the moon itself is slowed up is a false one. The tide on the earth has no influence in retarding the motion of the moon. There is no energy lost *at the source*, which is the moving, impinging particles that carry light and force all matter either to move or to remain relatively stationary.

The rate of rotation of the earth is the sum of many forces and counter forces, and the result is an exceedingly constant length of day steadied by inertia.

When a planet has a number of moons or satellites, the moons being of different periods will have their center of mass constantly shifting. The effect is to drag the primary around in an irregular course. The accelerating influence will be much greater, and the rate of rotation will be more rapid. This is the case with the great planets Jupiter and Saturn. Their rotation in about 10 hours is

very rapid when it is considered that the comparatively small earth, with its relatively large moon is rotating only once in 24 hours. This is the striking effect of the near approach of the moon's orbit to a circle.

The sun itself is forced to rotate by the action of the planets. Here again the shifting of the aggregate mass of the planets exerts a great rotating force. Particularly is this evident in the excess movement of the equatorial band and the generation of the heat under that band, which, by the gassifying of matter causes the blow-outs known as sun spots.

EDWARD GODFREY.

General Notes

The Rittenhouse Astronomical Society, of Philadelphia, held its monthly meeting on Friday evening, April 10, 1942, in the Little Theatre of The Franklin Institute. The speaker was Dr. Roy K. Marshall, Assistant Director of the Fels Planetarium, whose subpect was "Receding Horizons." The paper gave an explanation of some of the latest ideas concerning the farthest reaches of space.

American Astronomical Society

Upon the invitation of Yale University, the Society will hold its sixty-eighth meeting at New Haven, Connecticut, June 12-14, 1942.

Headquarters for registration will be at the Sterling Law Building of Yale University at the corner of Grove and High Streets, two blocks north and one block west from the northwest corner of the New Haven Green. The meetings of the Society will be held in this hall and a large lounge will be available for the use of members.

The University regrets that it cannot offer dormitory or dining hall facilities. The following hotels are recommended:

Hotel Taft, special rate, single room and bath, $3.50; room with twin beds and bath, $5.50; single and double rooms with running water, $2.75 and $4.50.

Hotel Bishop, special rate, single room with bath, $2.75, or $4.00 for two people; room with twin beds, $4.50.

Y.M.C.A., Y.W.C.A., a few rooms available at $1.50. The Y.W. requires a deposit of $1.00 at the time of application for room.

It is recommended that members make their own reservations in advance. Addresses for other tourist accommodations will be supplied on request to Yale Observatory.

Numerous restaurants are available in the vicinity of the hotels and near the Society headquarters.

TENTATIVE PROGRAM

Friday, June 12.

Morning: Teachers' conference. Council meeting at 10:00 A.M.
Afternoon: Opening general session; session for papers; reception.
Evening: Lecture.

Saturday, June 13.

Morning: Business meeting; session for papers.
Noon: Society photograph.
Afternoon: Session for papers; tour of University buildings.
Evening: Society dinner.

Sunday, June 14.

Morning: Session for papers, if necessary.

Noon: Lunch at the Observatory.

Afternoon: Excursion to Van Vleck Observatory, Middletown. (Tea will be served.)

PAPERS, ABSTRACTS, AND OBSERVATORY REPORTS

Titles of papers must be in the Secretary's hands by May 18 in order to appear on the printed program. The rules governing the arrangement of the program will be the same as at the Yerkes and Cleveland meetings. Precedence will be given to authors who expect to be present. Members who make definite advance arrangements for other members to read their papers, *and notify the Secretary* to that effect, will have the status of present members.

When two or more titles are presented by the same author, one only will be placed on the regular program, the others on a supplementary list to be called for if time permits. Joint authors may have more than one paper on the regular program if each paper is read by a different author. A non-member who gives a paper must be "introduced by" some specific member, and will be given the status of the member who introduces him.

Except by invitation of the program committee the maximum time for any paper will be ten minutes, with a warning signal two minutes before the end.

Authors are urged to send in abstracts before the meeting. The writing of an abstract previous to the presentation is one of the best ways of preparing to present a paper in the most concise and lucid form. One of my predecessors in office recommended also that authors rehearse their papers *aloud*, and suggested the dome as a suitable place for rehearsal.

Directors of observatories are reminded that reports for the year 1941-42 will be due July 1 (for the year ending June 30). It is especially important that these reports be submitted as early as possible this time, on account of the early date of the meeting.

DEAN B. MCLAUGHLIN, *Secretary.*

The Observatory, University of Michigan, Ann Arbor, Michigan,
April 15, 1942.

The Midwest Astronomers

The Midwest Astronomers held their spring meeting at the Yerkes Observatory, April 4. Attendance was normal in spite of transportation difficulties; general discussion revealed that for those astronomers not actively engaged in war-research problems, the major change during the last year has been the great increase in enrollment in navigation courses.

Professor Stebbins of the Washburn Observatory discussed recent observations with a photoelectric cell provided with six color filters. The wave-length regions observed reach from the infrared to the ultraviolet (10,000 A to 3,500 A). Giant and dwarf stars of a wide range of spectral type have been measured to obtain relative energy distributions. Departures from the black-body law are found, particularly in late-type giants; a preliminary calibration in terms of color-temperature was given. Another application of this technique to reddened B stars revealed a departure from the so-called λ^{-1} law of interstellar reddening, in a direction such as to require a larger ratio of absorption to observed color excess. The colors of many extragalactic nebulae were also observed photoelectrically. Their energy distributions are found to be far from those of a black-body; the

nebulae are also cooler than is expected on the basis of their spectral type. Part of the effect may be due to the mixture of the millions of stars of different types that make up a galaxy.

Professor Struve of the Yerkes Observatory reviewed our knowledge of stars with variable spectra. The most famous of these, α^2 Canum Venaticorum, has been known for a long time to possess a spectrum of type A, but with many peculiar lines. These lines show a strong variation in a period of about five days, and some of them were recognized as due to the rare-earth, ionized europium. Recent measures on high-dispersion plates taken at McDonald and Mount Wilson Observatories, have established the presence of other rare chemical elements such as ionized neodymium, dysprosium, gadolinium, holmium, and cerium. Other lines of more common elements such as iron, chromium, titanium, calcium, and magnesium are similar to those in normal A stars, and are constant or vary in opposite phase to the rare-earth lines. It is probable that all lines originate in one stellar atmosphere—but the theoretical explanation of the observed line variations is still to be made. Radial-velocity variations have not yet established any large pulsation of the star (such as is observed in Cepheids); the light varies by only a few hundredths of a magnitude.

Dr. Keenan of the Yerkes Observatory discussed some late-type stars of an interesting and peculiar group. They are particularly rich in carbon, with abnormally strong bands of the hydrocarbon compound, CH. McDonald spectrograms show that as an apparent consequence of the strength of CH the lines present in normal stars are wiped out. Without CH the spectrum probably would resemble that of a G giant; in fact, only the lines of ionized calcium, the hydrogen lines, ionized barium and strontium are strong in these stars—lines which are possible signs of high luminosity. All the rest of the strong lines in the spectrum are due to various bands of CH, including many not yet classified in the laboratory. One puzzling result of the investigation is that all the known stars with this essentially chemical peculiarity—abundance of a hydrocarbon, CH—also have high speeds with respect to the sun, up to 250 miles a second.

Dr. Baldwin of the Dearborn Observatory outlined a new interpretation of some lunar formations. Instead of the two usually antagonistic theories of the origin of seas, craters, and ridges—either the meteoritic or volcanic hypothesis—he discussed some consequence of the combined processes. An asteroidal body, perhaps 75 miles in diameter strikes and penetrates deeply through the crust. Lava flows form a sea, flood other seas and craters, while filling in the actual site of the impact. Centered on the region of impact there might be splash phenomena, such as radial lines of ridges, elliptical craters, and clefts cut into older formations. Some lunar photographs showed such radial formations in connection with a flooded area.

JESSE L. GREENSTEIN, *Secretary.*

Yerkes Observatory, Williams Bay, Wisconsin.

Book Reviews

Long Enduring Meteor Trains, by Charles P. Olivier. A large sized pamphlet of some 40 pages bearing the above title has been issued as Reprint No. 60 from The Flower Astronomical Observatory of the University of Pennsylvania.

It is taken from the *Proceedings of the American Philosophical Society*, issued in January, 1942. It represents work which has been in progress since 1935. Various persons contributed to the work under the direction of Dr. Olivier, who did the major part of the work. An extensive table of long enduring meteor trains is included giving 1336 entries with data regarding each. The earliest entry relates to an observation in the year 32 B.C., the last, in the year 1941. In years to come this compilation of data will be found very useful in carrying out any statistical studies concerning meteors which may be undertaken.

New Handbook of the Heavens, by Hubert J. Bernhard, Dorothy A. Bennett, Hugh S. Rice. (Whittlesey House, McGraw-Hill Company, Inc., New York City. $2.50.)

The "New Handbook of the Heavens" is a sequel to the "Handbook of the Heavens" by the same author. It is a sequel rather than a revision because it is completely rewritten and greatly enlarged. The features which made the former a success have been retained and new features added. The new volume is a handsomely bound book of 300 pages, and includes 45 half-tone illustrations and 30 line figures which help in clarifying the material presented. There are 18 chapters in the main body of the volume and 6 appendices. At the close eight pages are given to a glossary of astronomical terms, followed by an eleven page index.

In the several chapters are found simple and intelligible discussion of practically every question which will confront the beginner in astronomy. The chapter on Rainbows, Auroras, and Other Wonders, while not strictly astronomical, will throw light on questions which frequently arise in the minds of the average person as soon as he begins to think of the sky. An item which will be found very useful is a list of 57 telescopic objects, with brief, accurate descriptions of them. If the positions of these objects had been included, the list would be still more valuable especially to those whose telecopes are equipped with circles.

We cannot hope to point out all the commendable features in this book, but we can confidently say that the possessor of it will frequently turn to it for help in a comprehension of the elements of the science of astronomy.

C.H.G.

Publication Received.—The publishers of POPULAR ASTRONOMY hereby acknowledge receipt of the following named publication and express their great appreciation of the courtesy shown on the part of those who sent it.

"Occulation Reduction Elements for the Year 1942," Computed by the British Nautical Almanac Office. Published by the American Section of the International Astronomical Union.

LUNAR COSMORAMA

How I came to cross the waterless sea
Whose cindered level lies upon the moon
I shall not know—perhaps I was set free
Of body while I slept and made immune
To mortal needs—this much I know, that I,
A man alone, traversed a desolate waste
And climbed a pinnacle of rock so high
That I could almost touch the stars that raced
Through interstellar night around my head.
The earth, become a satellite, appeared
Absurdly unfamiliar. Meteors sped
Moonward without fire or sound. A weird
Zodiacal glimmer quivered in mid space
And then a slender arc of solar light,
Dim at first, transformed the place
Whereon I stood, its dawnshine falling white
Upon innumerable crater tops until
Their margins gleamed against the lunar land
Like circles made by fish upon the still
Dark surface of a lake. The saraband
Of dawning swung from slow to swift. Higher
Rose the sun until, grown terribly bright,
It flashed upon the vitreous spires like fire
Spilled on ice—an object of delight
And awe. No sheltering clouds or cooling showers
Spread their shade above the low plateaus
And flanking barriers of Alpine towers
Upon whose slopes no vegetation grows
To soften fearful facts: and yet I cried,
"Beautiful!"—although I made no sound
With moving lips. I felt my senses slide
Downward into darkness more profound
Than consciousness and when I wakened I
Was where I am—upon this watered sphere—
Breathing air . . . uplooking to the sky . . .
Waiting for the new moon to appear.

HARRY ELMORE HURD.
168 Dartmouth Street, Boston, Massachusetts.

POPULAR ASTRONOMY

CONTENTS

MAY, 1942

THE LUMINOSITIES OF NOVAE, Dean B. McLaughlin 233

TREDYFFRIN OBSERVATORY, BERWYN, PENNSYLVANIA, H. B. Rumrill 245

ERRORS IN "MARVELOUS VOYAGES—II" 249

ON THE BALANCING OF EQUATORIAL TELESCOPES, G. Van Biesbroeck 253

RECENT LIGHT VARIATIONS OF MU CEPHEI, Joseph Ashbrook .. 256

WAR WORK OF ASTRONOMERS, C. C. Wylie 259

Planet Notes for June, 1942 263

Occultation Predictions for June, 1942 264

Meteors and Meteorites 265

Meteor notes from the American Meteor Society,—Meteors and the Lunar Surface,—Contributions of the Society for Research on Meteorites: Cataclysm and Evolution; The Great Siberian Meteorite of 1908: Possibly a comet that struck the earth (review),—The Bucyrus (Ohio) meteorite hoax,—The daylight meteor of April 2, 1942.

Comet Notes 276

Comet 1942 *a* (Whipple),—Periodic comet Schwassmann-Wachmann (2),—Periodic comet Grigg-Skjellerup,—Comet 1929 II (Forbes),—Comet Wolf (1).

Variable Stars 278

Variable Star notes from the American Association of Variable Star Observers.

Communications and Comments 282

What makes the earth rotate?

General Notes 285

The Rittenhouse Astronomical Society,—American Astronomical Society,—The midwest astronomers.

Book Reviews 287

Long Enduring Meteor Trains,—New Handbook of the Heavens,—Publication received.

LUNAR COSMORAMA (poem), Harry Elmore Hurd 288

The principal articles of this magazine, beginning with Volume **15** (1907), are listed in the International Index To Periodicals.

Y

233
245
249
253
256
259
263
264
265
276
278
282
285
287
288